Positive tipping points:

Five case studies to accelerate the low carbon transition

In partnership with

Contents

Crossing the tipping point

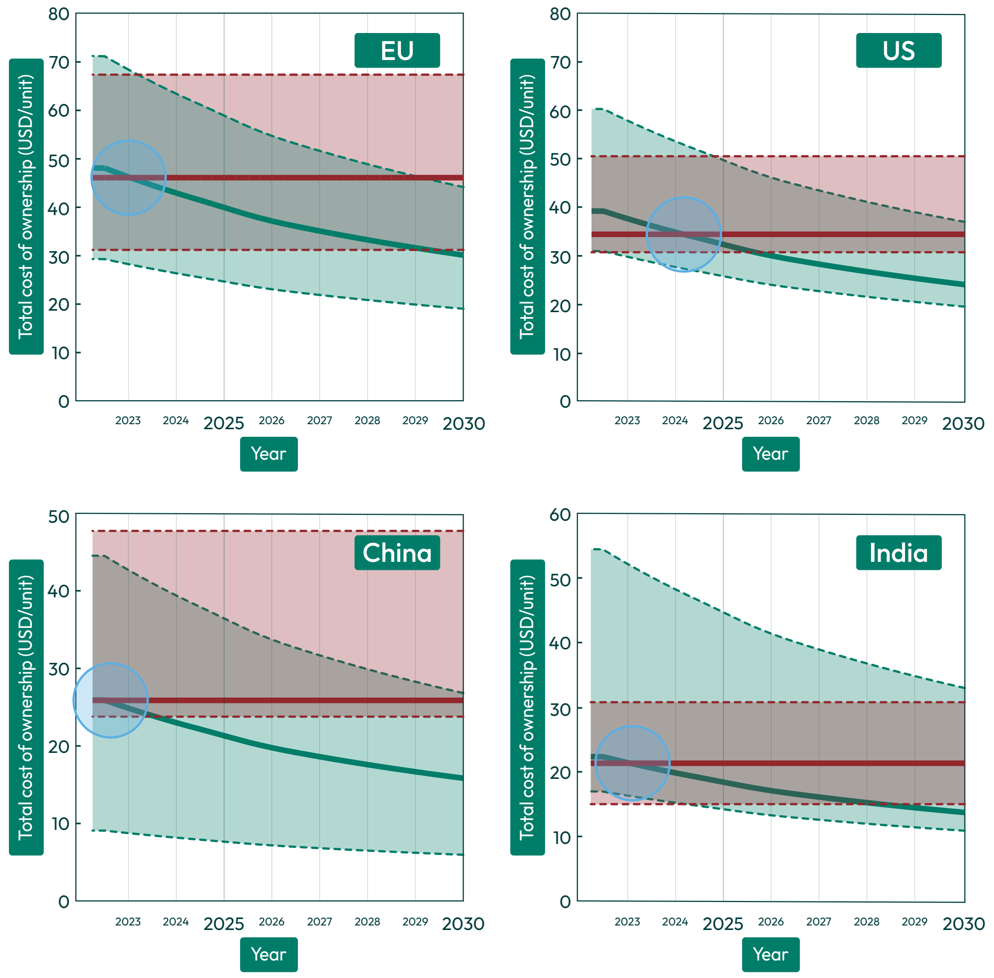
Electric Vehicles Case Study

Tipping point: current status

A first tipping point has been crossed: in leading markets, electric vehicles are already cheaper to own than fossil fuelled cars

- **A rapid shift to battery electric vehicles (BEVs)** is the most cost-effective way to decarbonise passenger road transport [1].
- **This shift will accelerate as BEVs cross 'tipping points'** where they outcompete fossil fuel cars first on the cost of ownership, then on purchase price [2].
- **In the EU and China, the first tipping point has already been crossed:** BEVs are already cheaper to own than petrol and diesel cars, in the small and medium-sized car segments, when both the purchase price and the cost of use are accounted for. In the US, this tipping point is likely to be crossed in 2024-5 [3].
- **These three markets have global impact,** accounting for 60% of the global car market. Their progress greatly increases economies of scale in battery production, bringing down the cost of electric vehicles for the rest of the world [4].

Sources: [1] Systemiq (2022) [2] Lenton & Sharpe (2021) [3] Barbrook-Johnson et al (2023) & EEIST modelling [4] BNEF (2023)



Fossil fuelled vehicle total cost of ownership

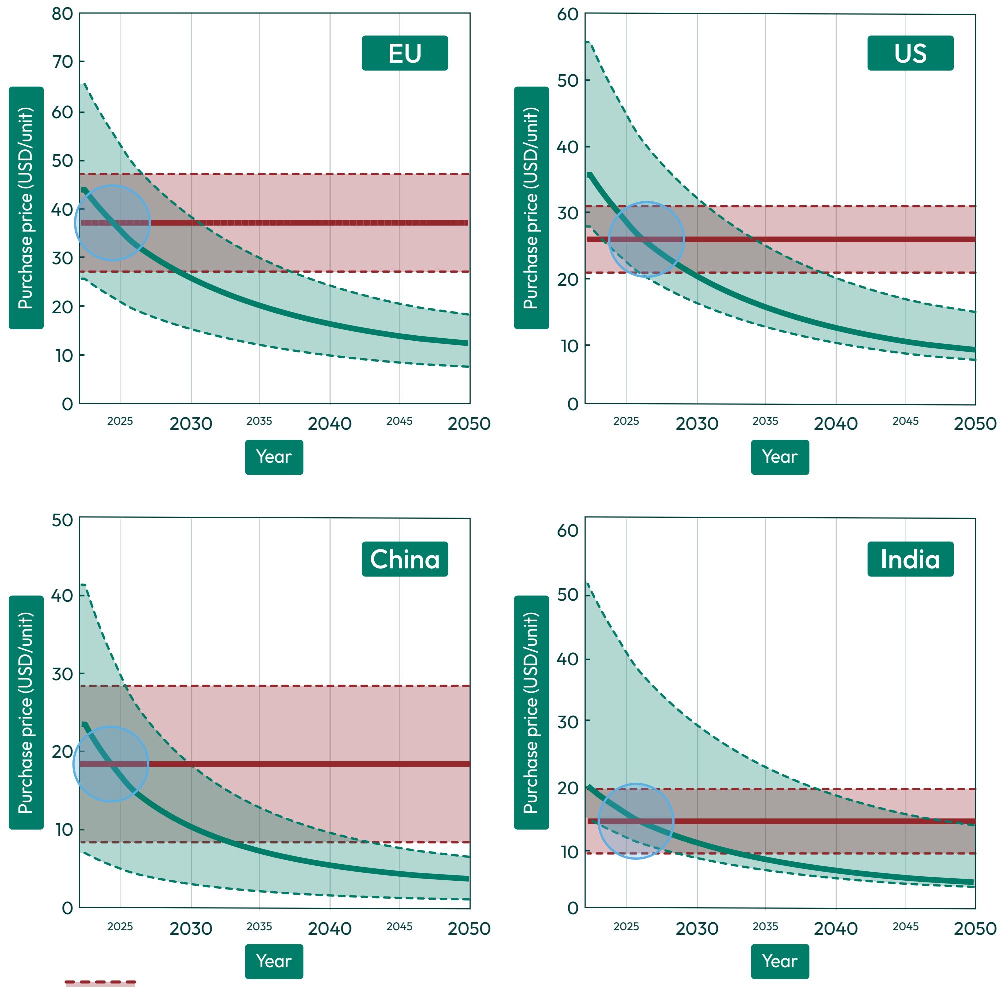
Electric vehicle total cost of ownership

Source: Lam, A. and Mercure, J.F., 2022. Evidence for a global electric vehicle tipping point.

A second tipping point is imminent: in leading markets, electric vehicles will be cheaper to buy than fossil fuelled cars within the next one to three years

- **The shift in consumer preference towards battery electric vehicles (BEVs) is likely to accelerate once upfront purchase price parity is achieved,** while range, model availability and charging infrastructure continue to improve [1].
- **This tipping point is expected as early as 2024 in Europe, 2025 in China, and 2026 in the US for medium-sized cars, and even sooner for smaller vehicles** [2]. It has already been achieved for some models – in China, the two best-selling BEVs in 2022 were priced at under $6,500 and $16,000, less than the equivalent fossil fuelled cars [3].
- **In other countries the tipping point is later, but still likely this decade** – in India it may occur around 2027 [4]. In Japan, it is likely to occur after 2030 given strong policy favouring hybrid vehicles [2].
- **These tipping point forecasts exclude subsidies,** so the tipping point for the consumer will be even earlier where governments provide them.

Sources: [1] IEA (2023); BNEF (2023); Ritchie (2023) [2] Barbrook-Johnson et al (2023) & EEIST modelling [3] IEA (2023) [4] EEIST modelling



ICEV purchase price

Electric vehicle purchase price

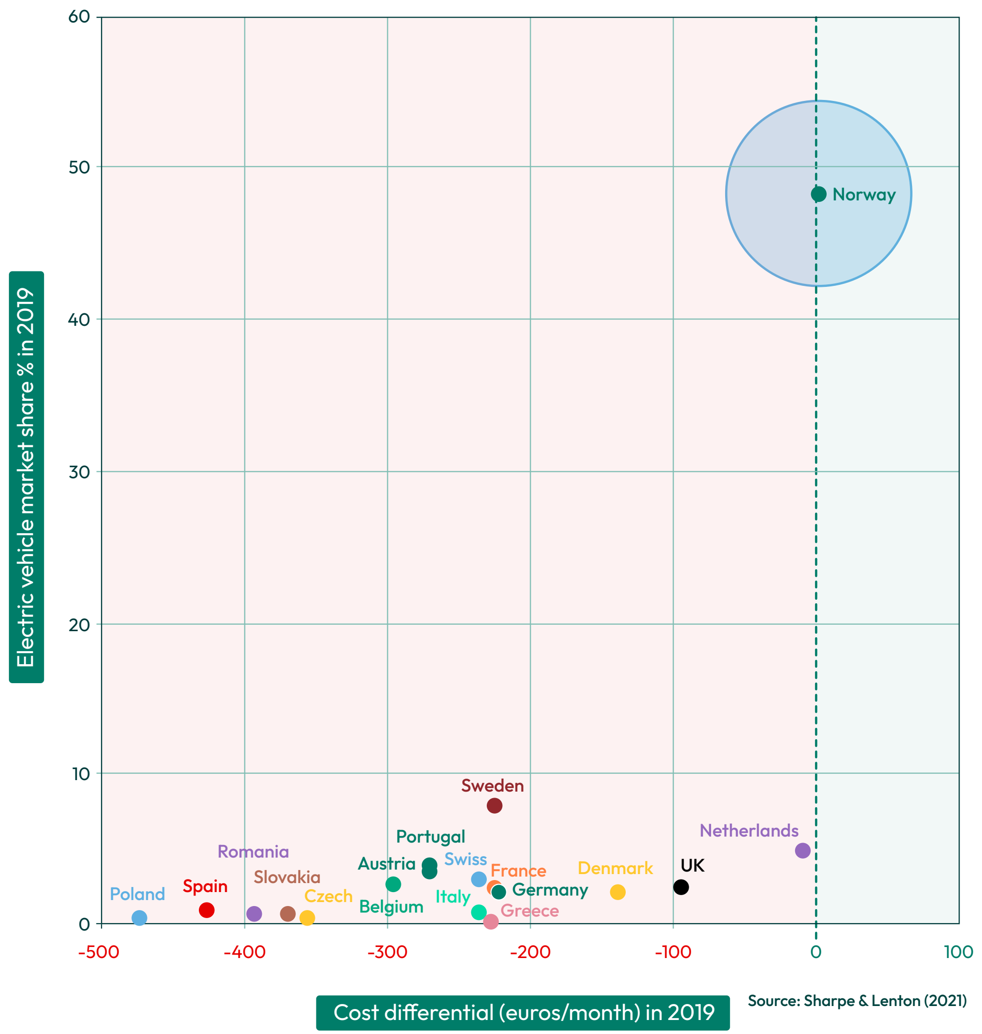
Source: Lam, A. and Mercure, J.F., 2022. Evidence for a global electric vehicle tipping point.

Passenger battery electric vehicles

Strong policy can bring forward tipping points by years

- **Norway achieved ownership cost parity in 2012, a decade ahead of the largest markets, and achieved purchase price parity in 2021.** Its policies included a combination of subsidies and taxes that made electric vehicles (EVs) cheaper to buy than fossil fuelled cars, preferential treatment for electric vehicles (access to bus lanes, and free parking) and investment in charging stations. This led to a tipping point in price, accessibility and attractiveness. Norway's EV share of car sales reached 18% in 2015, then 79% by 2022 (5 times the global average).
- **China crossed the price parity tipping point for small cars before any other large market,** through a combination of regulations to shift industry investment, subsidies for electric vehicle production and purchase, and public investment in charging infrastructure [2].
- **California is ahead of the rest of the USA, thanks to purchase subsidies and regulatory policy.** Its EV share of car sales stood at 25% in the first quarter of 2023, 3-4 times the level of the rest of the USA, and EVs are now its largest export [3]. The Inflation Reduction Act should help the rest of the USA catch up: it is expected to cut the purchase price of electric cars by $3,000 to $9,000 [4], accelerating adoption and bringing forward the price-parity tipping point.

Sources: [1] Bkerkan et al (2016); Figenbaum (2017); Norwegian EV Association (2023) [2] Anadon et al (2022) [3] CEC (2023); Reuters (2023); Utility Dive (2021) [4] ICCT (2023)



Source: Sharpe & Lenton (2021)

National policy recommendations

Zero emission vehicle mandates are the single most effective policy to drive the transition

- **Zero emission vehicle (ZEV) mandates ensure a complete shift to the new technology by requiring an increasing proportion of cars sold to be zero emissions.** This ensures a complete elimination of emissions, leaving nothing to chance [1].
- **ZEV mandates do the most to accelerate electric vehicle cost declines:** by ensuring the largest deployment of EVs in a given time period, they push the technology furthest down the learning curve.
- **ZEV mandates and efficiency regulations are both highly cost-effective approaches to increasing the uptake of electric vehicles.** They are considerably more cost effective as individual policies than subsidies and taxes, and have been central to the successes achieved by the leading markets of the EU, China, and California [2].
- **Contrary to traditional economic advice on carbon pricing, taxes used alone are the least cost-effective way to drive the transition.** However, they can be useful as part of a package of policies [3].

Sources: [1-3] Barbrook-Johnson et al (2023)

[1]**Subsidy:** an EV purchase subsidy set at the level required to achieve ownership cost parity with an equivalent fossil fuelled car in 2022
[2]**Tax:** a tax on fossil-fuelled vehicles set at the level required to achieve ownership cost parity with an equivalent EV in 2022
[3]**Regulation:** requires the carbon intensity of new vehicles to reduce linearly from its level in 2022 to zero by 2035.
[4]**Mandate:** requires all new vehicles to be zero emission by 2035

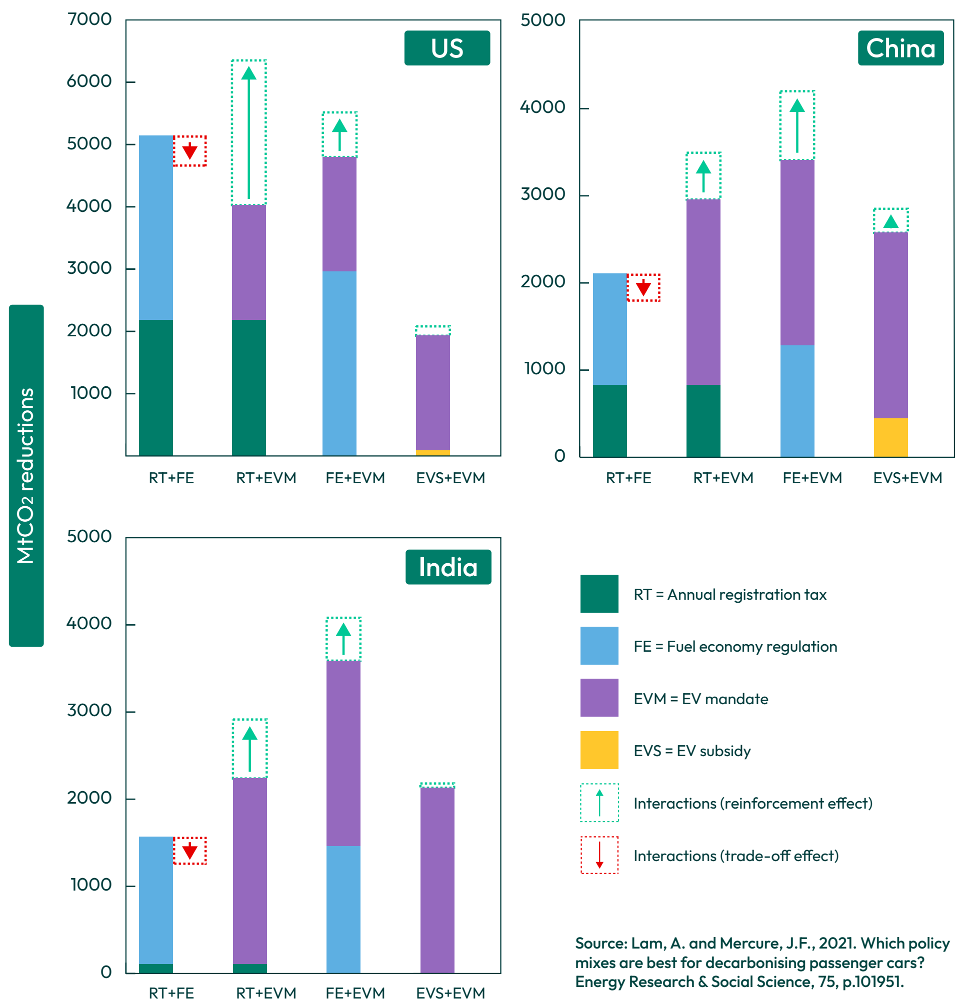
Source: Lam, Vercoulen, Mercure & Sharpe, in Barbrook-Johnson, P. et al (2023). New economic models of energy innovation and transition

Policy combinations can achieve more than the sum of their parts

- **The right policies used in combination can achieve more than the sum of their parts** – resulting in additional cost and emissions savings [1].
- **The greatest gains occur from combining electric vehicle (EV) mandates with other policies,** including efficiency regulations, road taxes, and purchase subsidies [2]. In all cases, infrastructure investment will be needed too.
- **Policy combinations have driven the growth of electric vehicle sales in the markets leading the transition,** including Norway, California, China, the EU, Canada and the UK [3].
- **Tax and subsidy combinations can cross the tipping point without needing government spending:** a small tax on each fossil fuelled car sale can fund a large subsidy for each electric vehicle, because electric vehicles are still a small share of the market. This is a revenue-neutral way to cross the cost parity tipping point [4].
- **Some policy combinations achieve less than the sum of their parts,** for example when efficiency regulations are combined with taxes [2].

Sources: [1] Lam & Mercure (2021) [2]] Barbrook-Johnson et al (2023) & EEIST modelling [3] CSE India (2023); Canadian Climate Institute (2022) [4] EEIST (2023)

Combining certain policies creates additional C02 emissions reductions



Source: Lam, A. and Mercure, J.F., 2021. Which policy mixes are best for decarbonising passenger cars? Energy Research & Social Science, 75, p.101951.

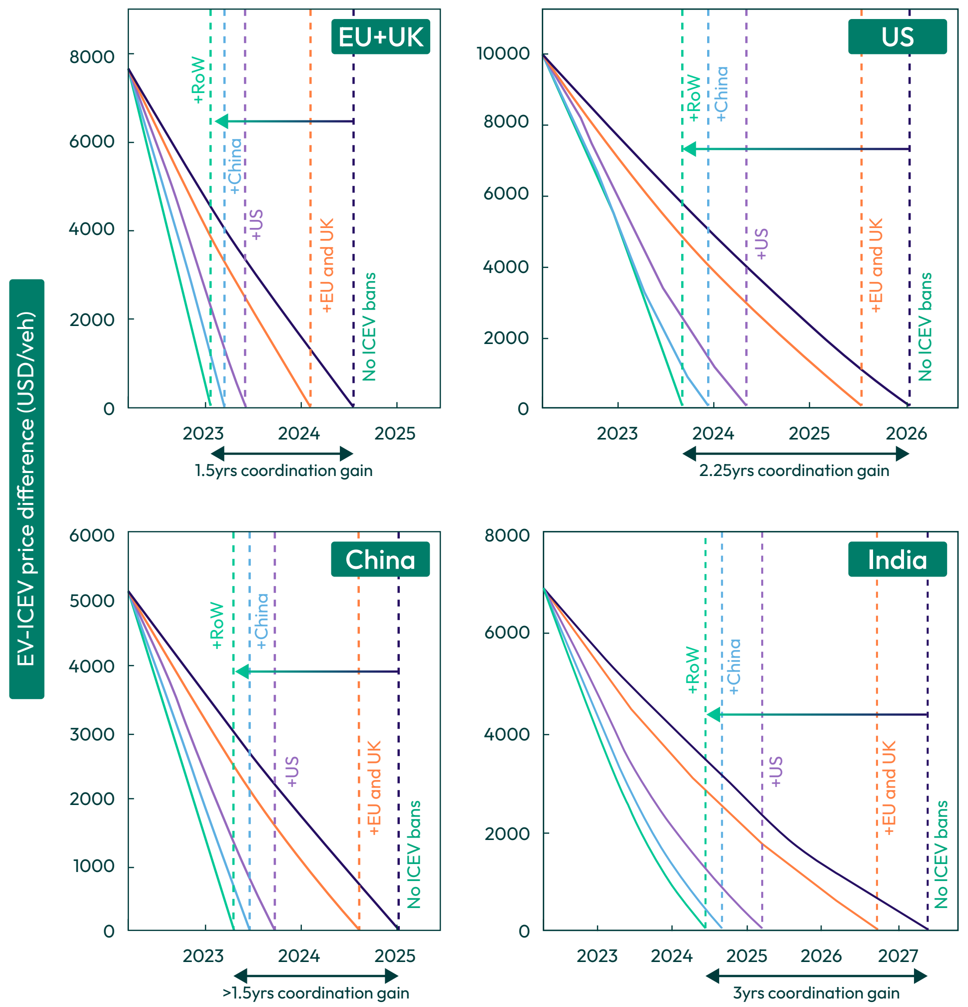
International action

Coordinated action among the largest markets can bring electric vehicle costs down faster than any country can achieve alone

- **If the EU, US, and China align their regulatory trajectories towards all new car sales being zero emission by 2035, this can bring forward national price parity tipping points by several years.** This happens because a faster transition in the largest markets scales up production, which drives faster innovation and lower costs [1].
- **This benefits all countries.** For example, coordinated action between Europe, the US and China could bring forward the electric vehicle (EV) / fossil fuelled vehicle price-parity tipping point in India by nearly 3 years [1].
- **Coordinated international action would have a greater impact now than later,** as price declines are steeper earlier in the transition [1].
- **Other forms of international cooperation that can accelerate the transition to EVs** include financial and technical assistance for emerging economies, particularly to facilitate investment in charging infrastructure, and harmonising standards for battery sustainability [2].

Sources: [1]] Barbrook-Johnson et al (2023) ; Lam & Mercure (2022) & EEIST modelling [2] Breakthrough Agenda (2022)

International coordination can bring forward price-parity tipping points



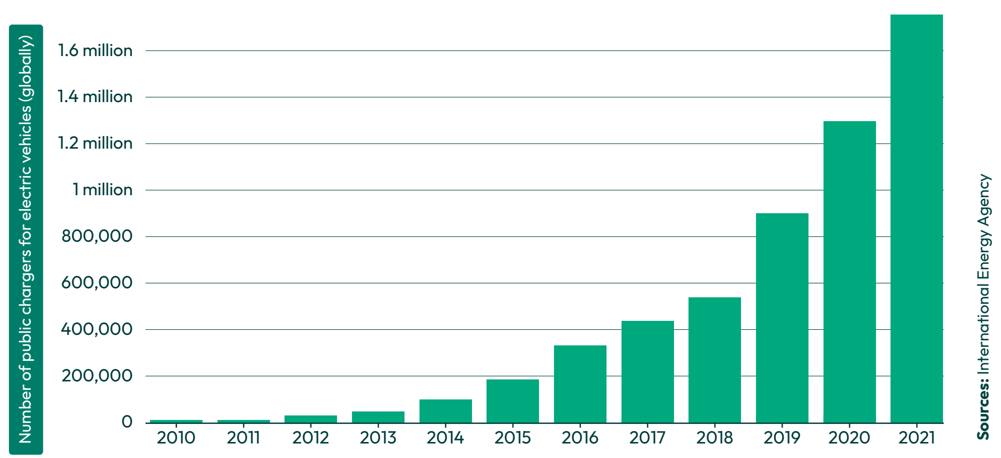
Source: Lam, A. and Mercure, J.F., 2022. Evidence for a global electric vehicle tipping point.

The challenges of charging infrastructure and material supply can be overcome, with proactive policy

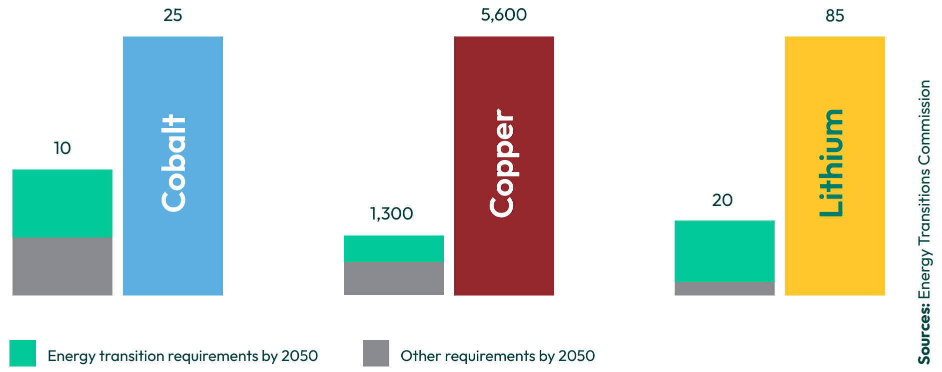
- **Globally, the global deployment of public chargers has roughly kept pace with the rise of electric vehicles (EVs) over the past five years,** staying at about 8-10 EVs per public charger. This indicates that charging infrastructure can keep up with EV deployment [1].
- **Proactive policy such as financial subsidies and incentives can accelerate charging infrastructure deployment.** With these policies, China became the largest charging infrastructure network in the world (now with only 7 EVs per charger), and the Netherlands built its total public charging points to 10 times the EU average [2].
- **There are enough mineral reserves** for the transition, and solutions are emerging to ease supply constraints and reduce prices. New lithium mines are rapidly starting production, near-total recycling of batteries has become technically feasible, and recycling policies are increasing in key markets [3].

Sources: [1] Ritchie (2023); IEA (2023) [2] Anadon et al (2022); ChargeUp Europe (2022) [3] Fast Company (2023); ETC (2023)

Public chargers are growing exponentially



There are sufficient materials
(Global reserves, million metric tonnes)

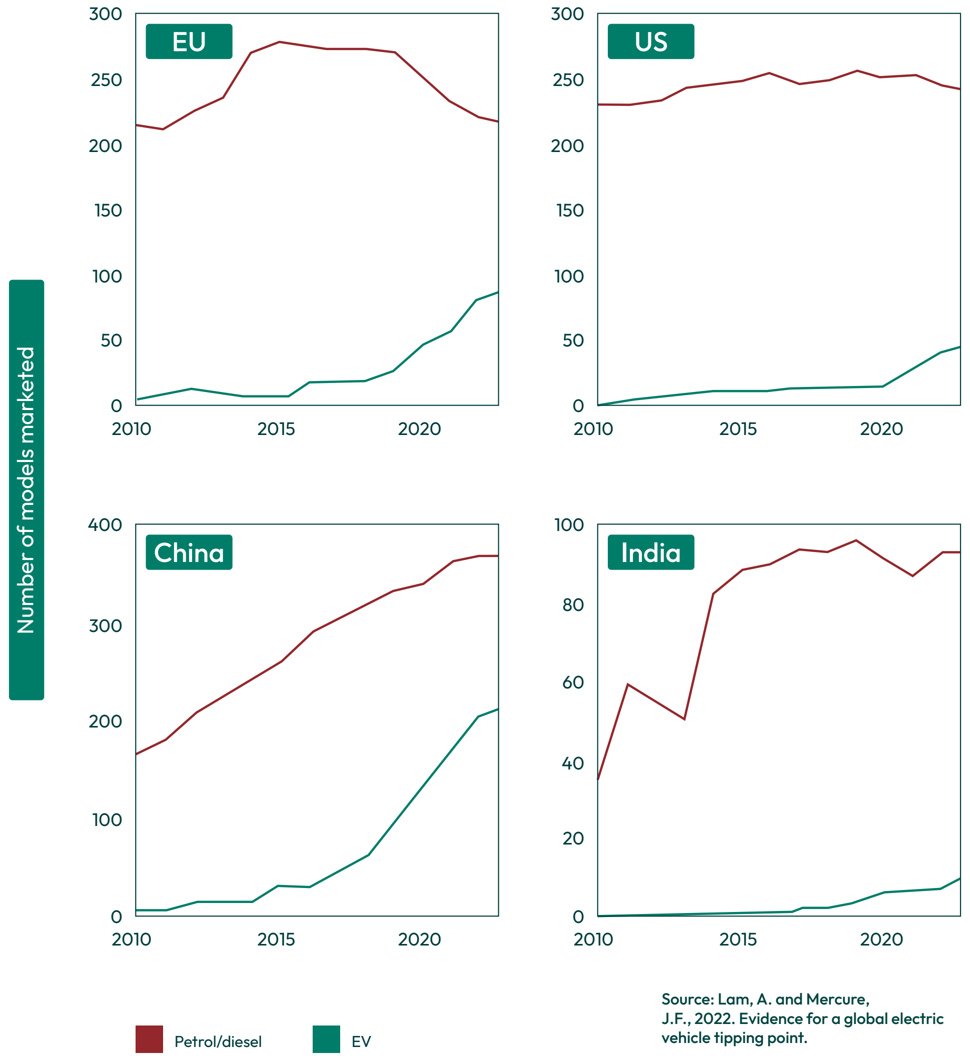


Wider benefits

There are many benefits of a fast electric vehicle transition: avoid expensive oil imports, create jobs and cut pollution

- **The transition can cut expensive oil imports.** Many countries spend huge sums on oil imports every year (China spent $365bn on crude oil imports in 2022, the US $205bn, India $173bn, Japan $102bn) [1]. Transport accounts for about two thirds of global oil demand [2]. The transition to electric vehicles (EVs) allows more of this money to be invested domestically instead.
- **Being a leader in the transition can be good for jobs and industrial competitiveness.** In 2022, top global automakers announced spending plans of nearly $1.2 trillion up to 2030 to develop and produce EVs, more than doubling estimates made in 2021 [3]. The number of different fossil fuelled vehicles on sale in leading markets is declining, while the variety of EV models is rising, clearly indicating the focus of new investment [4].
- **A rapid electric vehicle transition can save lives.** Emissions from fossil fuelled vehicles were linked with around 385,000 premature deaths globally in 2015, and the shift to electric transport could cut this by 75% [5].

Sources: [1] World's Top Exports (2023) [2] UN (2021) [3] Reuters (2023) [4] Barbrook-Johnson et al (2023); Lam & Mercure (2022) [5] ICCT (2019)



Source: Lam, A. and Mercure, J.F., 2022. Evidence for a global electric vehicle tipping point.

Crossing the tipping point

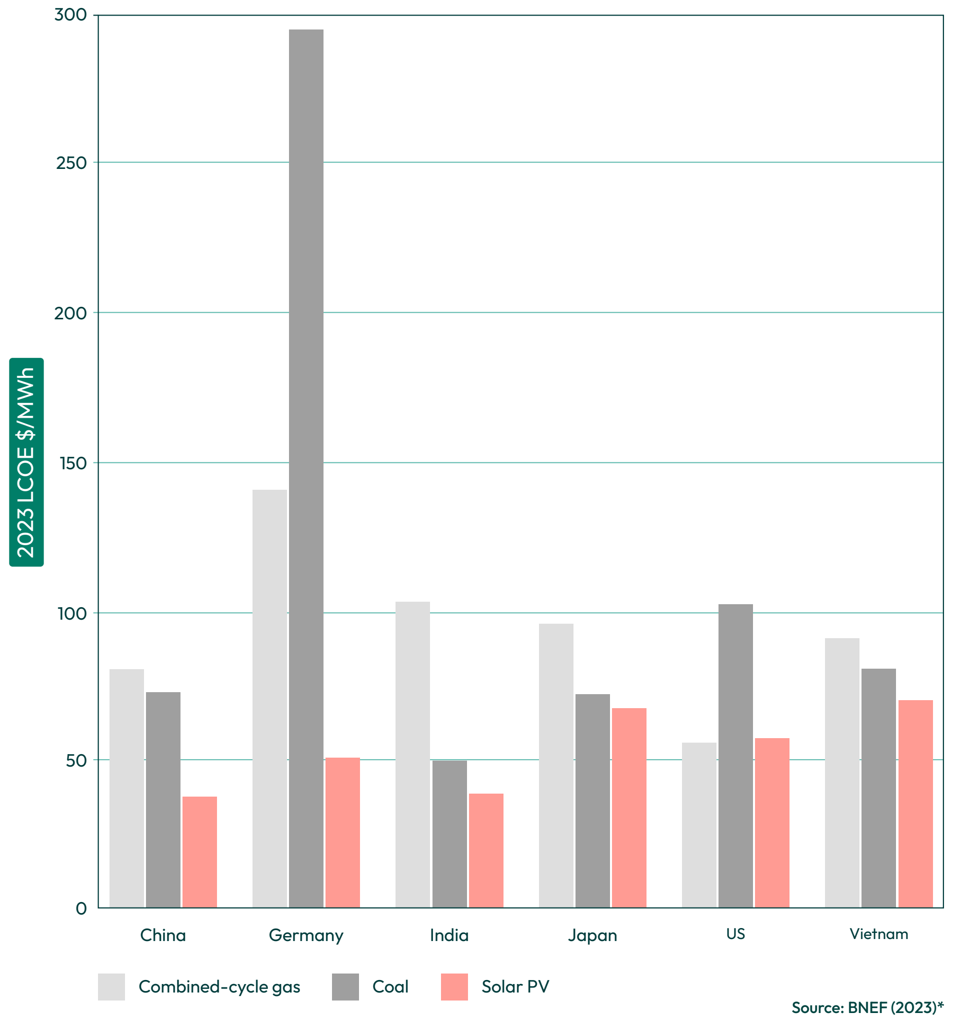
Solar and Storage Case Study

Tipping point: current status

For five years, new solar PV has been cheaper than new coal and gas in most of the world

- **Electricity from new solar PV is already cheaper than electricity from new coal and gas plants in markets including China, Germany, India, US, Japan and Vietnam.** Solar has a levelised cost of electricity (LCOE)* approximately 1.5 to 2.5 times lower than gas and 2 to 3 times less expensive than coal on average [1].
- **A rapid shift to renewables, with a prominent role for solar, is the most cost-effective way to decarbonise the power system [2].** As a result, solar PV is expected to dominate the mix, reaching 50% of global electricity generation by 2050 [3].
- **The cost gap is widening in renewables' favour,** with the cost of solar falling by 80-90% persistently each decade since 1960, while the costs of fossil-fuels are highly volatile, show no long-term decrease, and may increase in future as depletion is driving extraction from easy to harder-to-reach sources [4].

*LCOE is Levelised Cost of Energy and measures the average net present cost of electricity generation for a generator over its lifetime.
Sources: [1] BNEF (2023) [2] Nijsse at al. (2022) [3] Nijsse at al. (2022) [4] Way et al (2021); Kreps (2020)

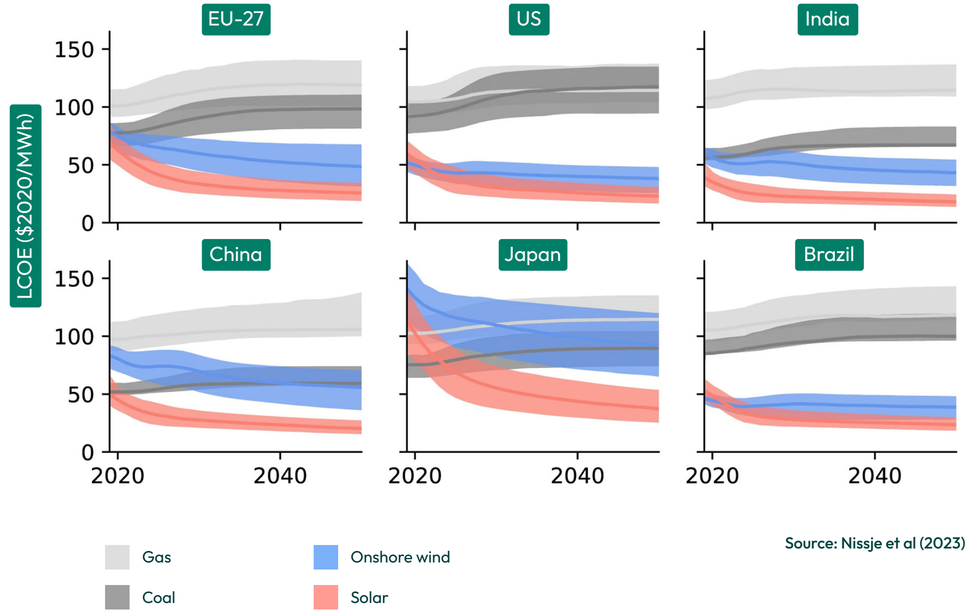


Source: BNEF (2023)*

New solar power plus battery storage will be half the cost of new coal power by 2030 in the largest markets

- **New solar plus storage is due to become cheaper than new coal in major economies this year (2023), except for Japan, when it should happen in 2025 [1].**
- **New solar plus storage is already cheaper than new gas power in the largest markets, where gas power tends to be more expensive than coal power [2].**
- **By 2030, in China, the US, the EU, Brazil and India, the cost of new solar PV & batteries will be at most half the cost of new coal power [3].**
- **Deployment in the largest markets will help drive down the cost of solar, wind, and batteries for all other countries.** Just five countries – China, the US, Japan, India and Germany – account for 63% of total global solar PV installed capacity [4]. Solar costs fall in proportion to cumulative global production, so these countries play an outsized role in making solar power cheap.

Sources: [1] Nissje et al (2023) [2] Nissje et al (2023) [3] Nissje et al (2023) [4] IRENA (2023)



Source: Nissje et al (2023)

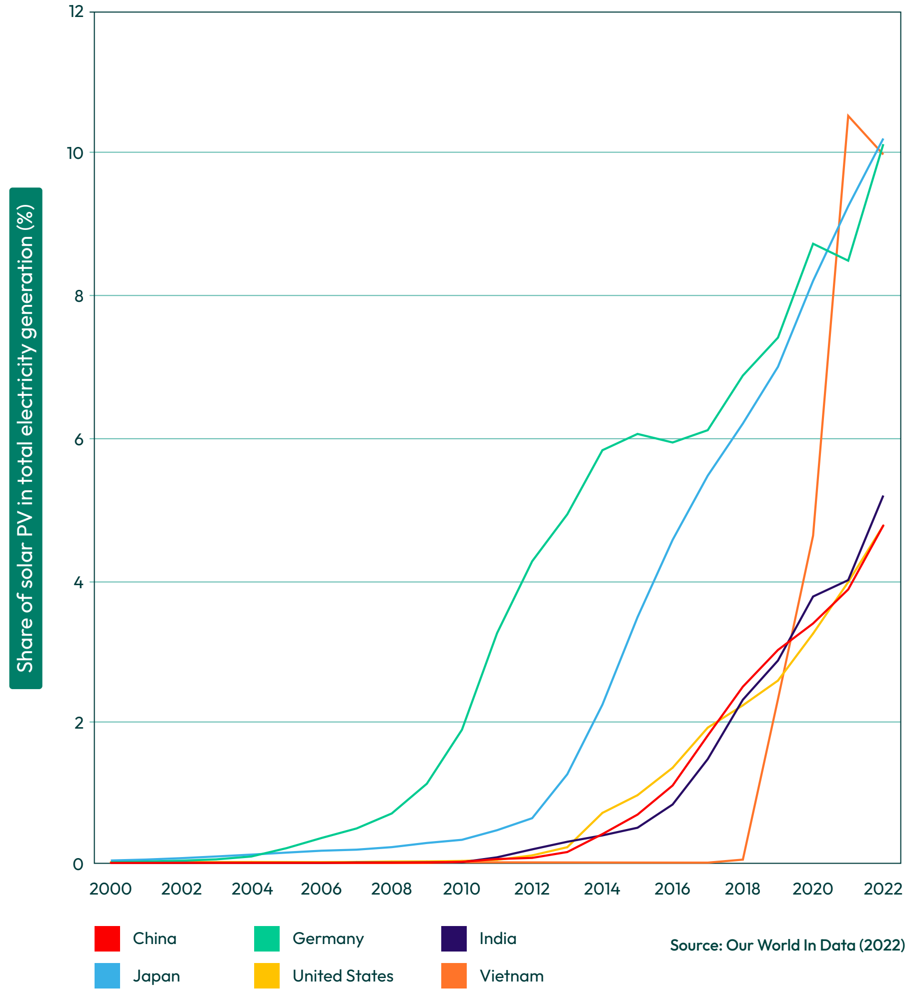
Solar and storage

Effective policies

Progress in the largest markets has been driven by feed-in tariffs; grid expansion is becoming ever more important

- **In Germany, solar PV feed-in tariffs induced large investment flows and cost reductions.** Together with China's investment in solar production and deployment, this brought the technology to mainstream markets [1].
- **In India, the National Solar Mission's** combined use of public procurement, waivers of inter-state transmission fees, grid expansion and specific subsidy schemes for rooftops and riverbanks resulted in the deployment of over 65GW of solar PV by 2022, compared to just 10MW in 2009 [2].
- **Japan implemented feed-in tariffs to diversify its energy mix** after the Fukushima nuclear accident in 2011. This led to solar's share of electricity generation increasing from 0.6% to 10.2% in ten years [3].
- **In Vietnam, a policy mix of targeted investment** including tax breaks and a bold feed-in tariff, and investments into transmission and distribution, drove exceptionally rapid deployment between 2018 and 2022 (though even more transmission lines and an updated pricing policy are now needed) [4].
- **More recently, the US's Inflation Reduction Act is now decreasing costs further** by providing production tax credits to battery cells and solar modules [5].
- **Non-price policies such as expanding grids, speeding up permitting, and incentivising deployment of energy storage are becoming ever more important** to maintain rapid growth in leading markets, while subsidies remain important in less developed markets.

Sources: [1] Nijsse at al. (2022) [2] Shrimali & Kekkalapudi (2014); IEA (2023); Government of India (2023) [3] IEA (2021) [4] Rapid Transition Alliance (2023) [5] Bricker & Eckler (n.d.)



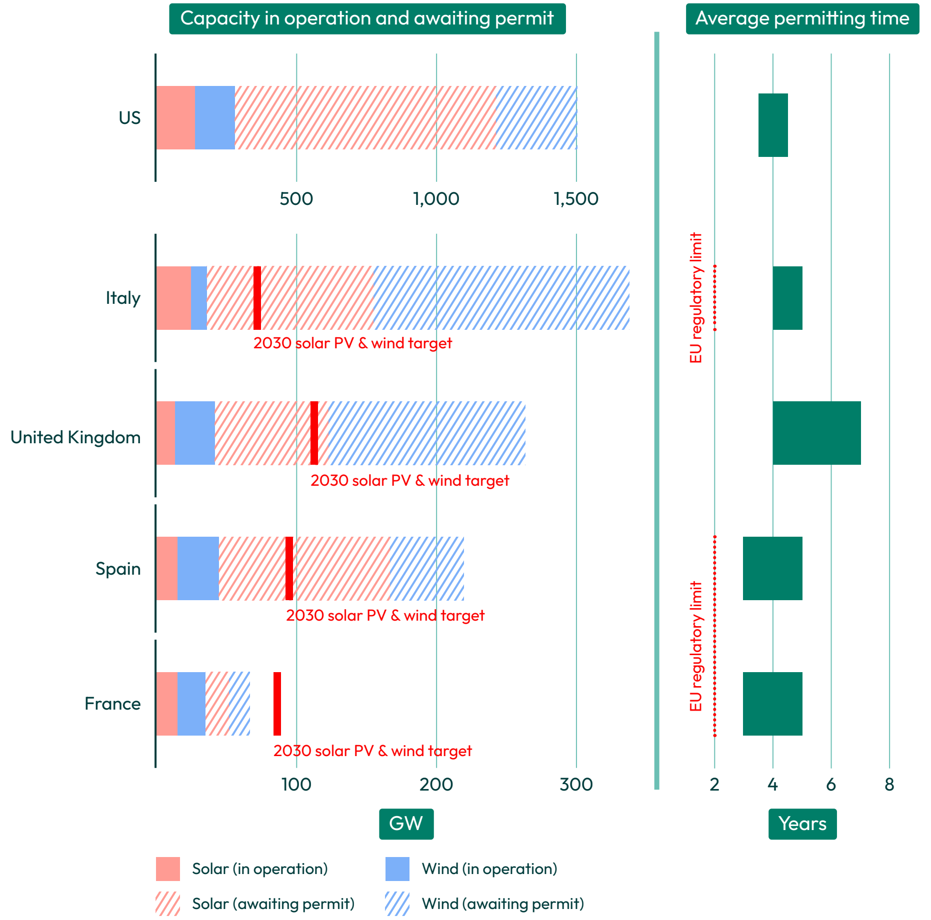
Source: Our World In Data (2022)

Priority policies

Policies to accelerate progress across the solar & storage tipping point

- **Long-term contracts that guarantee demand or price for solar power can accelerate deployment.** These can be in the form of Contracts for Difference, or Feed-in Tariffs (often with Power Purchase Agreements). In the UK, Contracts for Difference provide price certainty for offshore wind, and played a central role in reducing its cost to below that of gas power [1].
- **Reforming power markets can help make best use of the new technologies** For example, China's implementation of time-of-use power prices helped reduce demand at peak times and made distributed rooftop solar economical in cities where it wasn't previously [2]. Policies rewarding energy storage for its role in balancing supply and demand will incentivise further deployment, and cost reductions [3].
- **Grid expansion is crucial, to incorporate higher levels of solar and wind power.** Investments in electricity networks and system flexibility needs to more than double by 2030 [4]. Leading countries are responding to this need. China is investing in ultra-high voltage transmission projects, and India's Green Energy Corridor Phase II is channelling over $1.4 billion into grid capacity additions [5].
- **Accelerated permitting for new solar and wind farms is needed to ensure investment is not held up.** In the US and EU, over 500 GW of solar plants are awaiting permits. The EU has set a target of 2 years to approve new wind and solar plants, but this is still being regularly exceeded [6].

Sources: [1-3] Barbrook-Johnson et al (2023)



Notes: US, United Kingciom and France show capacity in December 2023; Italy shows capacky in January 2023 and Spain in March 2023; wind inckdes onshore and offshore.

Source: IEA (2023)

Opportunities for International Coordination

International cooperation can further accelerate the transition to low cost solar

- **The cost of capital is holding back investments in solar in developing countries. Financing costs can determine up to 50% of the cost of solar power in developing countries, deterring investment [1].** By one estimate, because renewables are capital intensive, their attractiveness decreases three times faster than that of gas-fired power plants for each percentage point increase in the cost of capital [2].
- By providing guarantees, advanced economies can reduce investment risks for developing economies, which in turn reduces the cost of their borrowing [3]. International risk guarantees could lower the LCOE by up to $31 per MWh in some regions [4].
- **Interconnectors can decrease the cost of electricity by helping to balance power supply and demand.** Interconnectors link the electricity systems of neighbouring countries and regions, allowing power to be transmitted from where it's abundant to where it's in demand. They make power systems more flexible and reduce the need for coal and gas plants to provide backup generation.
- By one estimate, interconnection could reduce the cost of electricity from 100% renewable-powered grids by around 31% in Europe, and 10% in North-East Asia and North America [5]. In West Africa, an interconnected regional power market could decrease the average cost of electricity generation by 25-33% [6].

Sources: [1] Lam & Mercure (2021) [2]] Barbrook-Johnson et al (2023) & EEIST modelling [3] CSE India (2023); Canadian Climate Institute (2022) [4] EEIST (2023)

Cost of capital across various countries

Country	S&P Rating	Climate Investment Risk Premium (CIRP)	Cost of Debt (Climate Project)	Required Rate of Equity Return (Climate Project)
Germany	AAA	1%	2.8%	8.3%
US	AA+	2%	5.3%	10.3%
Indonesia	BBB	9%	9.1%	14.7%
Brazil	BB-	14%	7.8%	22.2%
Nigeria	B+	17%	25.2%	30.8%
Tunisia	CCC+	23%	36.5%	42.1%

Source: CPI (2023)

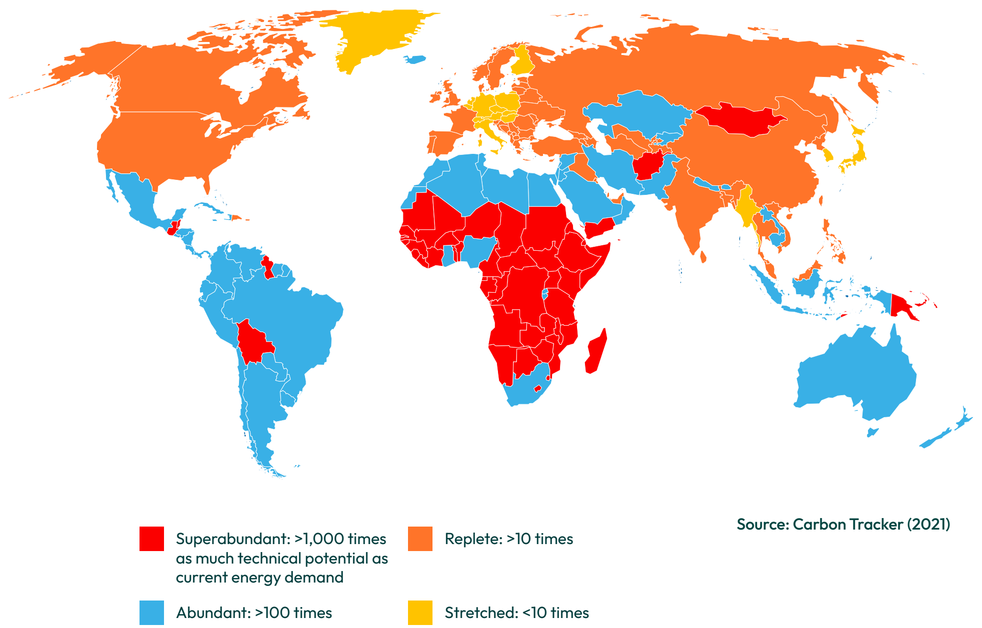
More jobs and cleaner air

Accelerating solar PV & storage deployment boosts access to affordable electricity and reduces local air pollution

- **The transition to renewables can cut expensive oil imports, allowing more money to be invested domestically instead.** 60% of people in Africa live in net fossil fuel importing countries, and most of sub-Saharan Africa has more than 1,000 times as much renewable energy potential as energy demand [1].
- **The transition to renewable power is enabling first-time energy access.** Solar-powered mini-grids and standalone systems are now the cheapest way of electrifying remote areas in Sub-Saharan Africa, where 600 million people lack access to electricity [2]. In Bangladesh, 6 million solar home systems have brought access to electricity to 20 million people in rural off-grid remote communities between 2020 and 2018 [3].
- **Being a leader in the transition can be good for jobs and industrial competitiveness.** Solar energy is currently the fastest growing source of new jobs among electricity generation sources, with the number of people in related jobs having increased 45% between 2017 and 2022 to a total of 4.9 million [4].
- **A rapid transition can save lives. Coal-burning is a major contributor to air pollution that is harmful to public health.** An estimated one in five deaths globally every year are attributed to fossil fuel pollution (coal, petrol and diesel), which contributes to asthma, lung cancer, coronary heart disease and strokes [5].

Sources: [1] RMI (2022) [2] Egli et al (2023) [3] BSS (2018) [4] IRENA and ILO (2023) [5] Vohra et al (2021)

Solar and wind energy potential as a multiple of energy demand



Source: Carbon Tracker (2021)

Crossing the tipping point

Hydrogen
Case Study

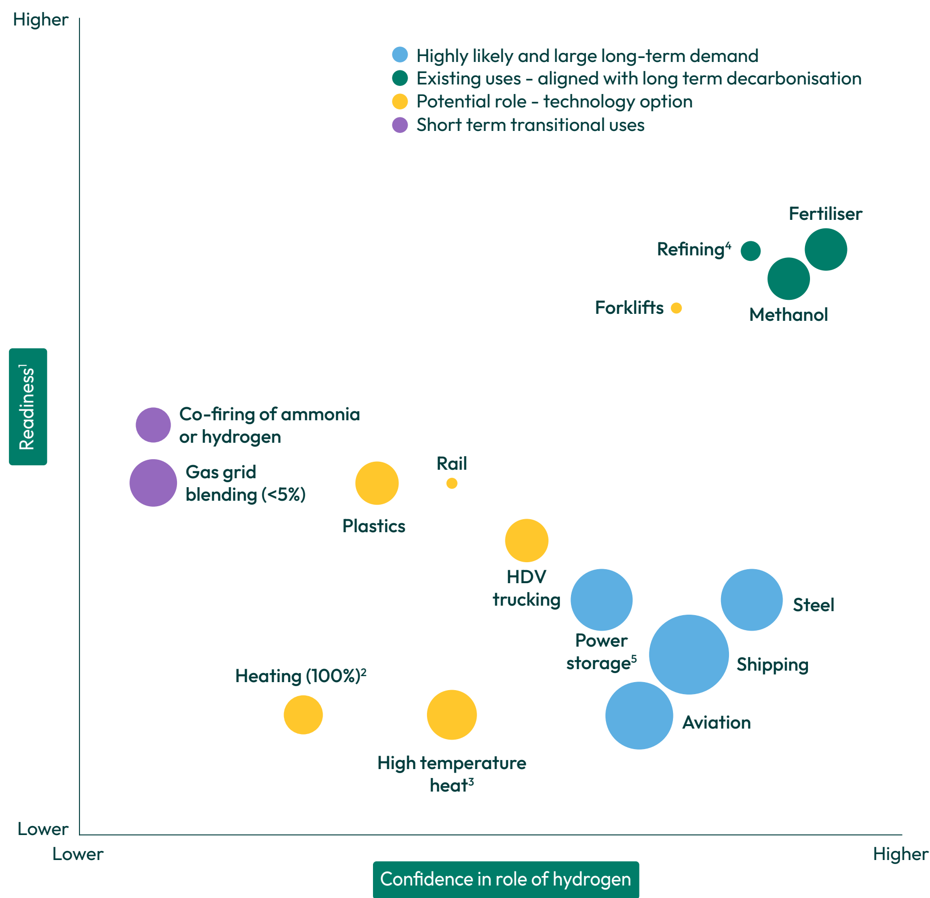
Hydrogen could be important to decarbonising some sectors of the economy

- **Electrifying as much as possible while fully decarbonising electricity supply is at the heart of global decarbonisation,** and electricity could supply over 70% of final energy demand [1].
- **In some sectors, direct electrification is likely to be impossible or prohibitively expensive, making hydrogen's properties useful as a second energy carrier.** Hydrogen could supply 13-24% of final energy demand by 2050, according to different scenarios from IEA, IRENA, ETC, Hydrogen Council, and BNEF [1].
- **Over 60% of the demand for green / low carbon hydrogen by 2030 is likely to be in sectors where 'grey' (fossil fuel derived) hydrogen is already used,** such as fertilisers, methanol and refining.
- Other sectors where hydrogen is most likely to be needed for decarbonisation include steel, shipping, long-term energy storage, and aviation.

* Grey hydrogen is produced from natural gas without abatement, green hydrogen is produced from electrolysis using renewable energy, and blue hydrogen is produced from natural gas with carbon capture. Blue hydrogen is not the focus of this case study.

Source: [1] ETC (2021)

Some applications of green hydrogen can provide early 'off-take'



NOTES:

1 Readiness refers to a combined metric of technical readiness for clean hydrogen use, economic competitiveness and ease of sector to use clean hydrogen.
2 'Heating (100%) refers to building heating with hydrogen boilers via hydrogen distribution grid,
3 'High temperature heat' refers to industrial heat processes above ca. 800°C
4 Current hydrogen use in refining industry is higher due to greater oil consumption.
5 Long-term energy storage for the power system.

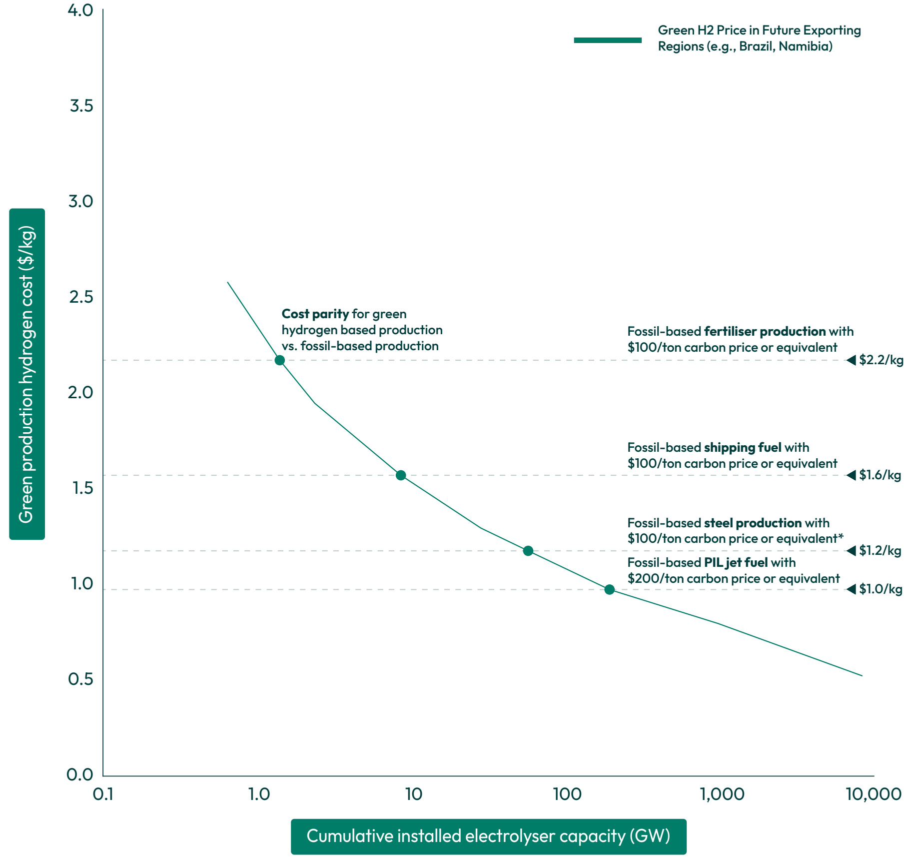
Source: ETC (2021)

The biggest opportunity for rapid growth and cost-reduction is in sectors already using fossil fuel hydrogen

- **While green hydrogen is currently more expensive than grey and blue, it will in time become the cheapest source of hydrogen,** due to rapid cost declines based on economies of scale and learning-by-doing [1].
- **The greatest opportunity to scale up green hydrogen quickly - to build economies of scale and reduce costs - is in the sectors where grey hydrogen is already used.** These include ammonia production for fertilisers, crude oil refining, and methanol production [2]. Here, green hydrogen can deliver a like-for-like replacement, requiring no technological innovation. This graph shows how increasing cumulative production – by sector, starting with fertilisers – can rapidly reduce costs.
- **Using green ammonia in fertiliser production may be the best opportunity to quickly scale-up green hydrogen technologies,** given that (i) it has one of the lowest additional costs of using green hydrogen to decarbonise, among all sectors (ii) green ammonia can be shipped at relatively low-cost and (iii) it can be produced at low cost in areas with rich renewable resources, and then transported to fertiliser production sites competitively [3].
- **A 25% blending mandate globally for green ammonia use in fertilisers could create enough demand to reduce green hydrogen prices to $1.5/kg** in locations with cheap renewable electricity, in turn helping unlock price-parity tipping points in green ammonia use for shipping and green hydrogen use in steel production [3]. This would accelerate deployment and further cost reductions, enabling its spread across multiple applications.

Sources: [1] BNEF (2023) [2] ETC (2021) [3] Systemiq (2023)

Impact of growing green hydrogen deployment by sector on production costs



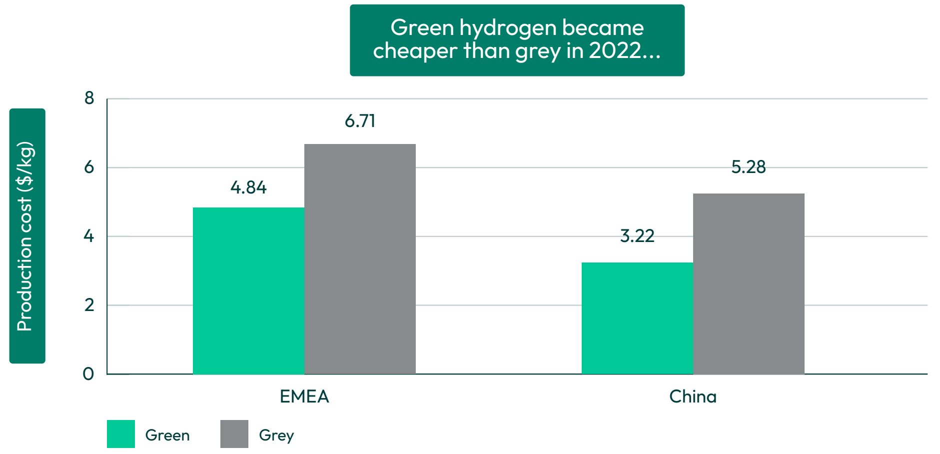
Source: Systemiq (2023)

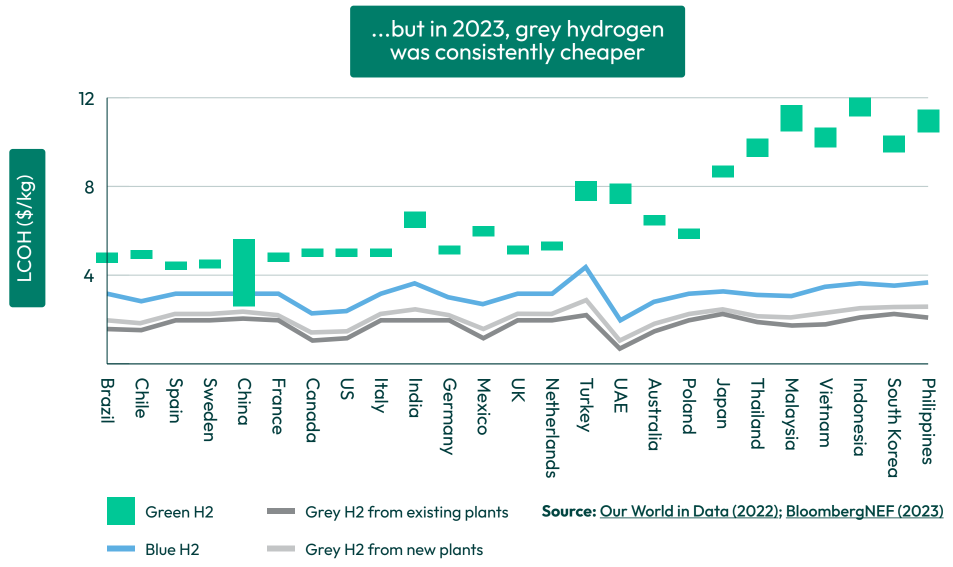
Hydrogen

Green hydrogen has already been cheaper than grey hydrogen at times of high gas prices

- **Green hydrogen is already cost-competitive with fossil-fuel based hydrogen in ideal locations with the lowest renewable electricity costs [1].**
- **When the Ukraine war pushed up natural gas prices by over 70%, the cost of green hydrogen became substantially less than the cost of new grey hydrogen in Europe, the Middle East, Africa and China** (before accounting for carbon prices) – something 'unimaginable' two years earlier [2].
- **By 2023, after gas prices fell, green hydrogen was consistently more expensive than grey again [3].**
- **The spike in gas prices rapidly accelerated investment commitments and pledges to build green hydrogen production capacity.** Global commitments made in the few months after the outbreak of the war totalled $73 billion, and will increase the speed at which green hydrogen's production costs fall to under $2/kg [4].

Sources: [1] IRENA (2020) [2] RMI (2022); Recharge News (2022) [3] BNEF (2023) [4] Carbon Tracker (2022)





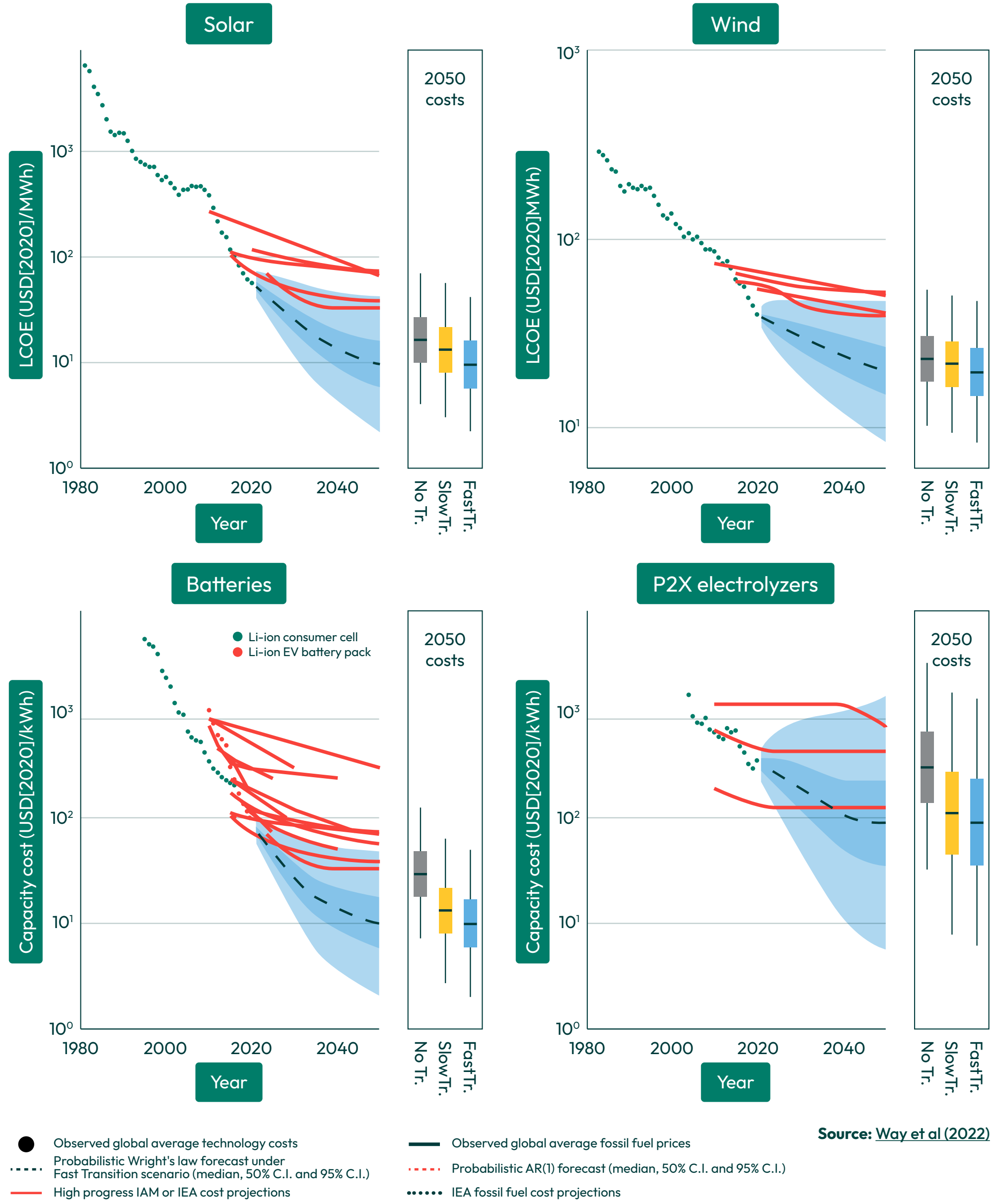
Source: Our World in Data (2022); BloombergNEF (2023)

Both key components of green hydrogen costs are rapidly getting cheaper

- **Both the main components of green hydrogen costs – renewable electricity, and electrolysers – are benefitting from rapid technology learning curves with exponential cost declines.** The cost of solar power has persistently fallen by 80-90%, and wind power by 70% each decade since 1960. The cost of electrolysers, similarly, has fallen 73% over the past 20 years [1].*
- Meanwhile, there is no obvious long term price decline in fossil fuels such as coal, oil, and gas: inflation-adjusted prices now are very similar to what they were 140 years ago [1].
- **This means that although green hydrogen is currently more expensive than grey hydrogen, it will in time undercut grey hydrogen and become the cheapest source of hydrogen in all markets.**
- **While electrolysers today are the main cost in green hydrogen production, electricity costs will become more important as electrolyser costs decline.** This more closely links the green vs grey hydrogen price-parity tipping point with renewable power deployment, which continues to outpace expectations [2].
- While recent increases in commodity prices may slow down cost declines in the near term, they are unlikely to stop cost declines over the longer term [3].

*Note there is some subjectivity and uncertainty in such a claim, as reported costs have significant variation. It also refers only to proton exchange membrane (PEM) electrolysers: other types have not improved this quickly.

Sources: [1] Way et al (2022) [2] BNEF (2023) [3] IEA (2023)



Source: Way et al (2022)

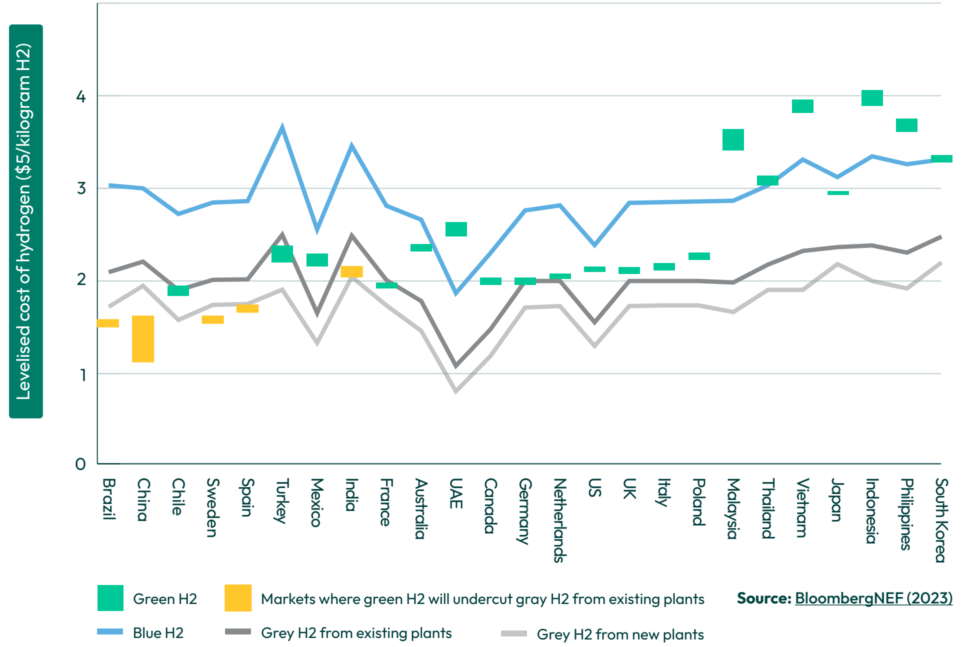
Hydrogen

Green hydrogen will be cheaper than grey hydrogen in leading markets by 2030 – and will eventually undercut grey hydrogen everywhere

- **By 2030, new green hydrogen will be cheaper than new grey hydrogen production in at least 8 countries, and 18% cheaper than continuing to run an existing grey hydrogen plant in Brazil, China, Sweden, Spain and India.** This is even without any subsidies for construction of the green hydrogen plants [1].
- If large-scale deployment of green hydrogen takes place, the costs of producing green hydrogen using electricity from solar PV could fall to $1.6/kg by 2030 in regions with the best sunlight, such as Africa, Australia, Chile, China and the Middle East [2].
- **Widely available and cheap renewables, combined with proactive policy,** are the key drivers underpinning cost-competitiveness across these leading markets. Where there is little sun or wind, the potential for clean hydrogen is much lower [3].
- **Green hydrogen is expected to undercut new grey hydrogen in over 90% of countries by 2035, and eventually in all of them [1].** The timing depends on uncertain factors including electricity prices, interest rates, land prices (affecting the cost of renewables), electrolyser efficiency and costs, and government policies [4].
- Many countries in sub-Saharan Africa, the Middle East and Latin America have plentiful renewable energy resources but there is huge uncertainty about the extent to which they will be able access capital at lower cost, enabling investment to take advantage of these resources [3].

Sources: [1] BNEF (2023) [2] IEA (2023) [3] IRENA (2022) [4] Way et al (2022); ETC (2021)

Green hydrogen is cheaper than gray in five markets in 2030



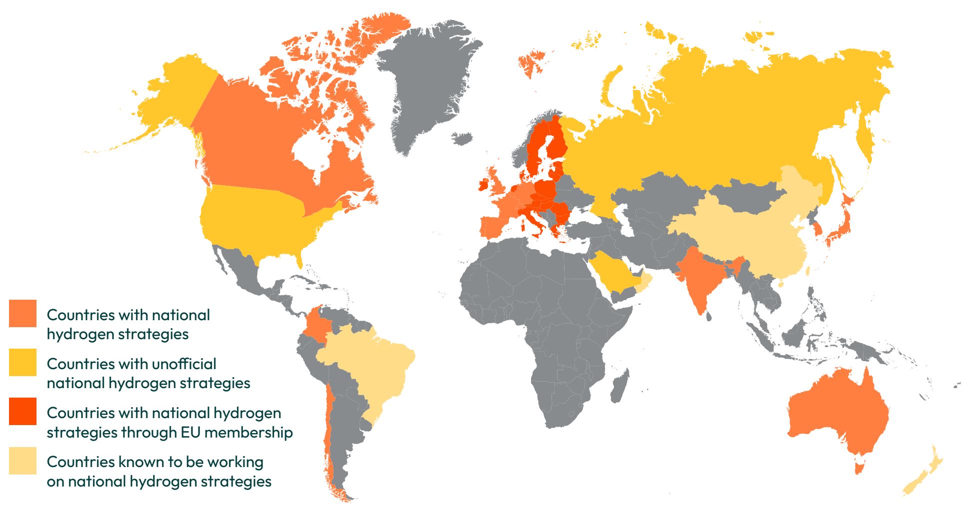
Source: BloombergNEF (2023)

National policies to bring forward the tipping point

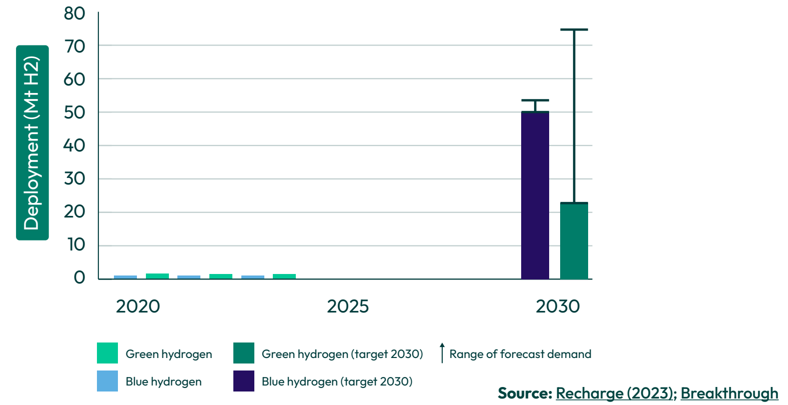
- **Strong policies can accelerate cost reduction and bring forward price-parity.** These include policies that: i) create demand and accelerate deployment of green hydrogen in sectors where grey hydrogen is already used; ii) improve financing and investment conditions; and iii) enable initial experimentation and learning in sectors where hydrogen has not been used before.
- **The most urgent priority is to create demand for green hydrogen in the sectors where it is needed.** Announcements to supply green hydrogen far exceed its current demand. Most of the demand-creation policies currently in place focus on road transport, where hydrogen may not be much needed. Far fewer focus on industry and refining.
- **Key policies to drive demand-creation include public procurement (e.g. requiring green steel in publicly funded construction); mandates or regulations such as those requiring blending of green ammonia in fertiliser production; and subsidies for green hydrogen use.** The EU quota for the use of 'renewable fuels of non-biological origin' in industry, transport and aviation by 2030 is a leading demand-side incentive for green hydrogen globally. India's hydrogen strategy envisages mandates for green ammonia use in fertiliser production (5% by 2023/24; 20% by 2027/28) [1].
- **Financial incentives can include contracts for difference (CfDs), tax breaks, subsidies and concessional loans, and carbon pricing.** The UK, Germany and Japan have or will introduce varying CfD schemes [2]. The United States' tax credits subsidise new green hydrogen assets by $3/kg, meaning new assets achieve LCOHs lower than $2/kg (compared to an average cost without subsidy of $4.5/kg) [3].
- **Demonstration projects are needed to test, prove and learn from the use of hydrogen in new sectors.** Creating hydrogen valleys (specific areas where the entire hydrogen value chain of supply and demand is clustered together) can help to de-risk investments and galvanise long-term funding [4]. The EU, Japan and US are all investing in hydrogen research, development and demonstration. The US Bipartisan Law provides USD$1 billion for R&D of clean electrolysis and $0.5 billion for manufacturing and recycling of clean hydrogen technologies over five years, and $8 billion will support hydrogen hub demonstration projects [5].

Sources: [1] BNEF (2023); IEA (2023) [2] IEA (2023) [3] Carbon Tracker (2022) [4] Breakthrough Agenda (2023); Mission Innovation (2023) [5] BNEF (2023)

Most countries have or are working on a hydrogen strategy...



...but deployment policies need to catch up

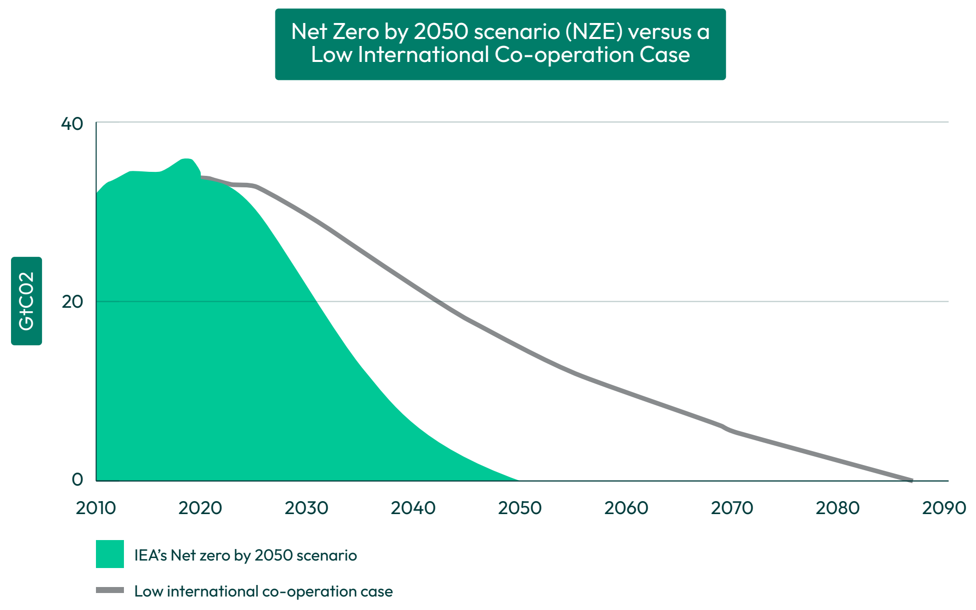


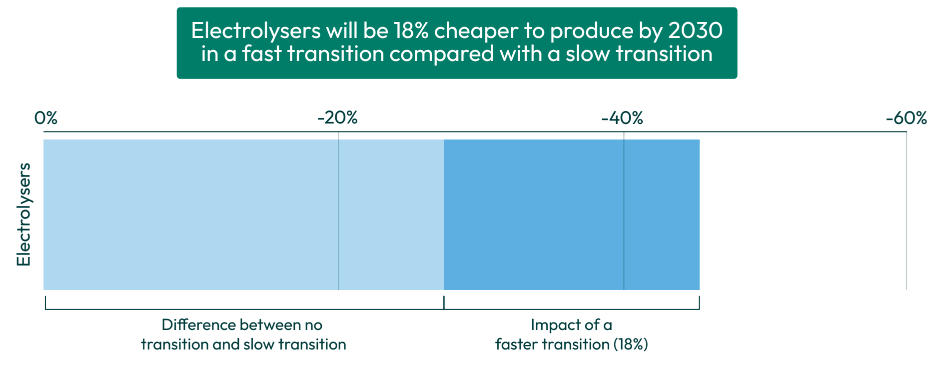
Source: Recharge (2023); Breakthrough Agenda (2023)

Coordinated international action to bring forward the tipping point

- **A fast global transition can only be achieved by countries taking coordinated action – no single country can make this happen on its own.** Indeed, net zero could be delayed by decades, and be more expensive, without international cooperation.
- **Standards and certifications, demand creation, technology demonstration, and finance,** are key priorities for international cooperation on green hydrogen [1].
- **Harmonised standards and certifications** are needed for governments to decide exactly which hydrogen can benefit from subsidies and trading, and to build investor and consumer confidence in the green hydrogen market [2].
- **Coordinated targets and policies** to deploy green hydrogen in sectors where grey hydrogen is already used would send a strong demand signal, mobilise investment in production, and enable larger economies of scale and faster cost reductions [1].
- **Sharing learning from demonstration projects in priority sectors can accelerate innovation and commercialisation.** Too many projects are focused on road transport; countries should share learning from demonstrations of hydrogen use in heavy industry, maritime shipping, aviation, and inter-seasonal electricity storage [1].
- **Governments need to work together with international financial institutions to identify ways to overcome project delays and reduce costs of capital [1].** Many projects are struggling to move from announcement to investment and construction. Doubling the cost of capital from 5% to 10% increases production costs by almost 40% [2], making this an important factor to address.

Sources: [1] Breakthrough Agenda (2023) [2] IEA (2022)





Source: IEA (2021); Breakthrough Agenda (2022)

Crossing the tipping point

Heat Pumps Case Study

Tipping point: current status

Heat pumps are already cheaper to own than boilers in leading markets

- **Successfully decarbonising residential heating requires the widespread adoption of highly efficient heat pumps, powered by low-emissions electricity [1].** Heat pumps are already less emission-intensive than fossil fuel boilers in almost all countries [2]. The emissions intensity of heat pumps will only decrease over time as fossil fuels continue to be phased-out of the power sector.
- **A tipping point, where it is cheaper to own (buy and run) a heat pump than a fossil fuel boiler, has already been reached in some countries, including Denmark and Italy.** High gas prices can increase heat pumps' advantage[a] [3].
- **In markets that are further behind, such as Canada and Germany, this tipping point can be brought forward with the right policies, such as subsidies or mandates.**
- **Further deployment of heat pumps is likely to bring down their purchase price and increase their performance**[b] so that they produce more heat for each unit of electricity.
- **Air-to-air heat pumps are the cheapest type of heat pump to own** but the popularity of different types is influenced by the heating infrastructure that each country has. In central European countries such as Germany, where water-based heating systems with radiators are widely used, air-to-water heat pumps have a much larger market share [4].

a Data on the short-term price of fuels taken from: Eurostat - Energy statistics - natural gas and electricity prices. Long-term fuel prices taken from the FTT-Power model.

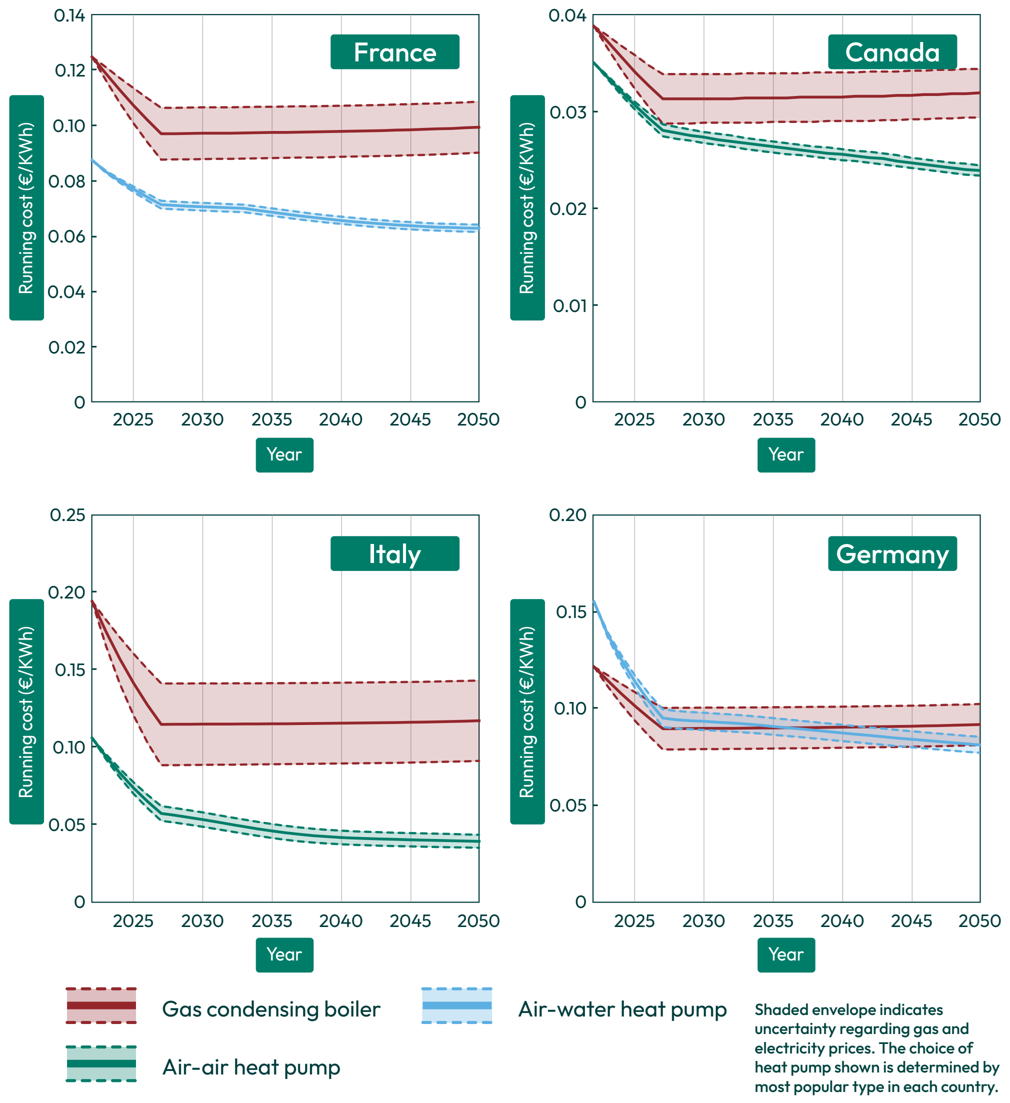
b Heat pump learning rate assumptions taken from: Junginger & Louwen (2019)

Sources: [1] IEA (2022), [2] Knobloch et al. (2020), [3] FT (2023), [4] IRENA (2022)

Heat pump running costs are typically cheaper than gas boilers – reducing exposure to gas price spikes and reducing fuel poverty

- **Heat pumps are 3-5x more efficient than a typical fossil fuel boiler [1].** This means that, even though electricity is generally more expensive than gas, it can be cheaper to run a heat pump than a gas boiler.
- **Where electricity prices are particularly high, so that gas or oil boilers are initially cheaper to run, policy can reduce or reverse the difference.** In some countries, such as Denmark, consumers pay a lower rate of tax on their electricity if they own a heat pump [2].
- **The cost savings from running a heat pump compared to a gas or oil boiler are likely to increase over time.** As well as improving in efficiency, heat pumps will benefit from renewables increasing their share of power generation, which is likely to reduce the price of electricity [3]. Any increase in gas prices would further increase heat pumps' advantage.
- **The lower running costs of heat pumps can reduce people's exposure to fuel price spikes** such as those currently seen in Europe due to the Russian invasion of Ukraine. This can help to decrease fuel poverty [1]. It can also help people living in rental accommodation, if heat pumps are installed by landlords.

Sources: [1] EHPA (2023), [2] IEA (2022), [3] Way et al. (2022), Nijsse et al. (2023)

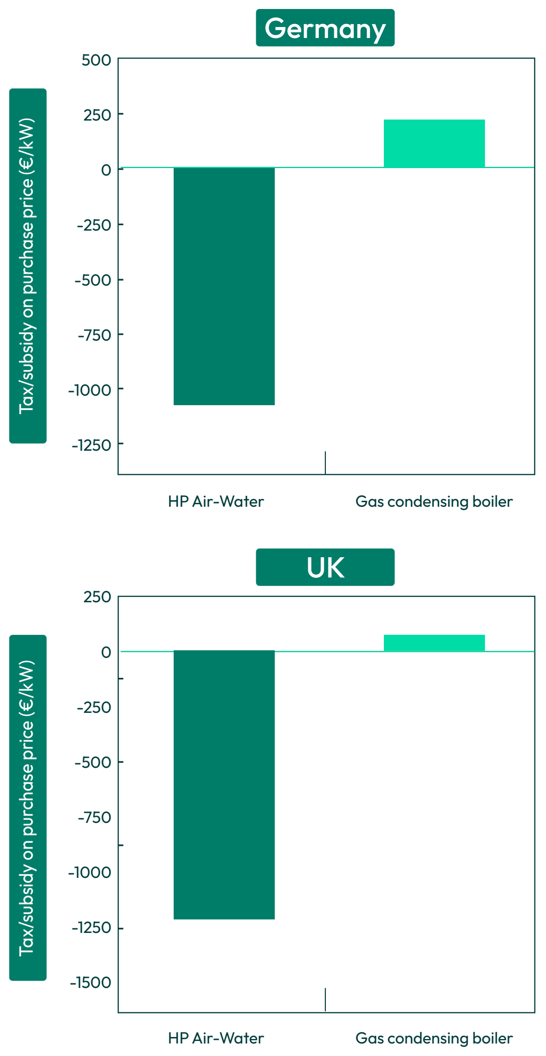


Revenue-neutral subsidies and better finance mechanisms can help to overcome purchase price barriers

- **Despite lower running costs, the purchase price of heat pumps is almost always higher than that of fossil fuel boilers.** A large part of this difference is due to higher installation costs, particularly when retrofitting existing buildings [1]. In most countries, policy will be needed to overcome this difference.
- **Purchase price parity can be achieved through a revenue-neutral 'feebate'.** This is where heat pump subsidies can be paid for by taxing gas boilers at the point of purchase. This makes heat pumps more attractive to consumers without placing additional financial pressure on governments. Such a scheme would be most suitable in countries where heat pumps have a small share of the market.
- **Loans with low or zero interest will also help to overcome high purchase prices and can help consumers move to heat pumps and save money in the longer term.** This can especially help lower-income households, who will benefit most from the lower running costs that heat pumps can provide. Several countries already offer such schemes [1].
- **Denmark has made heat pumps cheaper to buy than fossil fuel boilers** using a combination of tax exemptions, subsidies, and an innovative "heat as a service" scheme, where companies own and maintain the heat pump and households pay a subscription [2].

Sources: [1] IEA (2022), [2] DEA (2021)

Revenue neutral 'feebates' that make heat pumps cheaper to buy than gas boilers



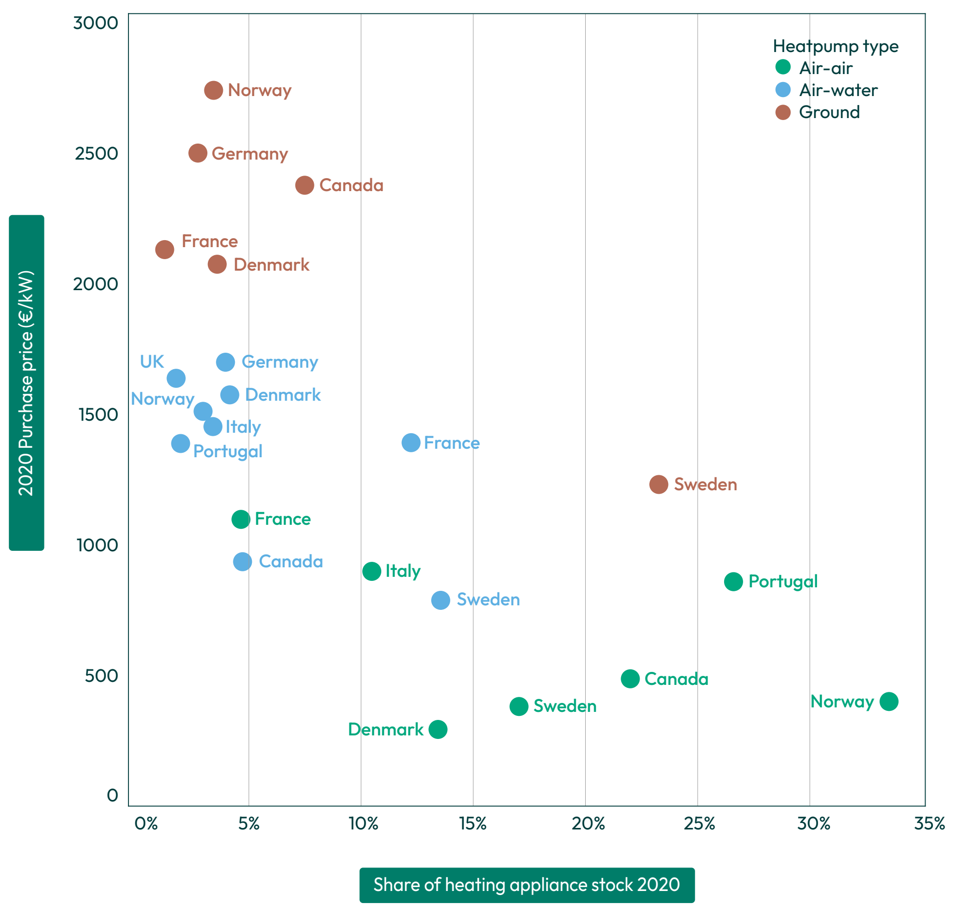
Market leaders

Heat pump prices are lower in countries that have grown larger markets for them

- **The purchase price of heat pumps is significantly lower in countries where heat pumps have a larger share of the heating market.** This is because larger markets can bring down costs through economies of scale and learning-by-doing [1].
- **Scandinavian countries* have the highest heat pump market shares, and the lowest heat pump purchase prices.** Their policies, which were motivated by a desire to reduce exposure to oil price spikes [2], provide an example that other countries can follow. Sweden has used a combination of carbon and energy taxes, subsidies, and building regulations to move away from oil and electric heaters towards district heating and heat pumps [3]. It now has heat pumps that are half the price of those in other European countries.
- **Warmer countries that already have significant air-conditioning markets, such as Portugal and Italy, are not far behind.** This is because many air conditioners are 'reversible', meaning they can also provide space heating.
- **Ground source heat pumps typically have the highest purchase cost and are the most complex to install.** However, their running costs, particularly in colder climates, are usually lower than air-to-water heat pumps.

***Heat pumps offer much more efficient heating than gas boilers and electric heaters even at temperatures well below freezing [4].** This is despite frequent questions of heat pump operability at low temperatures. Back-up heaters may only be required in extremely cold climates where temperatures reach below -10°C.

Sources: [1] Knobloch et al. (2019), [2] Rosenow et al. (2022), [3] Gross & Hanna (2019), [4] Gibb et al. (2023)

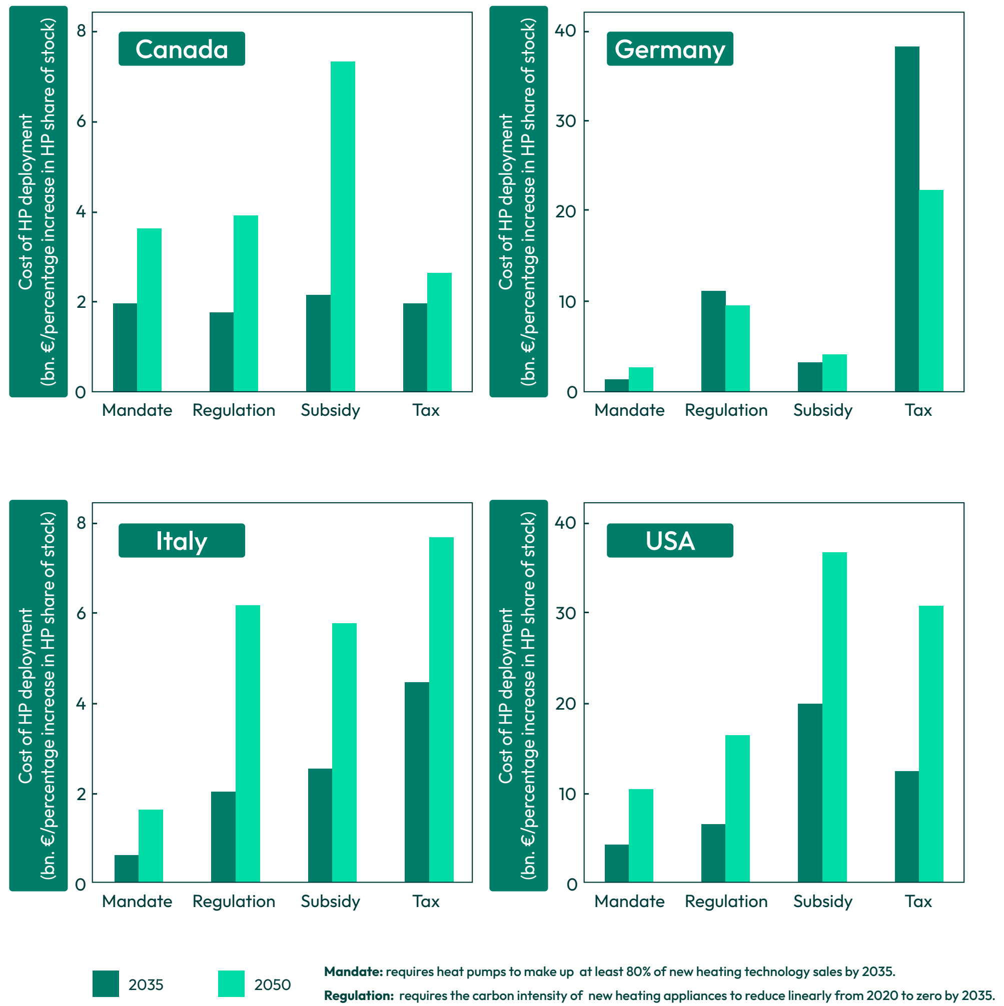


National policy recommendations

Heat pump mandates are likely to be the most cost-effective policy to accelerate deployment

- **Mandates on the sale and installation of heat pumps are likely to be a more cost-effective policy than subsidies and taxes to increase heat pumps' market share.** Mandates would require manufacturers of fossil fuel boilers to ensure that a rising portion of their sales come from heat pumps. This forces a reallocation of industry investment, improving the technology as the market grows.
- **Mandates are not yet commonly used for heat pumps, but their effectiveness has been demonstrated in the transition to electric vehicles [1].**
- **Subsidies are typically more cost-effective than taxes.** This is because early in the transition, subsidies are only applied to a small part of the heating market while, to be effective, taxes must cover the larger fossil fuel boiler share of the market. However, taxes can be more cost-effective where a sizable heat pump market is already established (e.g. in Canada, where heat pumps make up a large share of heating appliance sales).
- **As well as being relatively cost-effective when used alone, mandates can also be viewed as an 'enabling' policy [2].** This means that they can enhance the effects of other policies including regulations and taxes by increasing the size of the heat pump market.

Sources: [1] Lam & Mercure (2022), [2] Lam & Mercure (2021)



Mandate: requires heat pumps to make up at least 80% of new heating technology sales by 2035.

Regulation: requires the carbon intensity of new heating appliances to reduce linearly from 2020 to zero by 2035.

Subsidy: on the purchase cost of heat pumps set to achieve ownership cost parity with fossil fuel boilers in 2023.

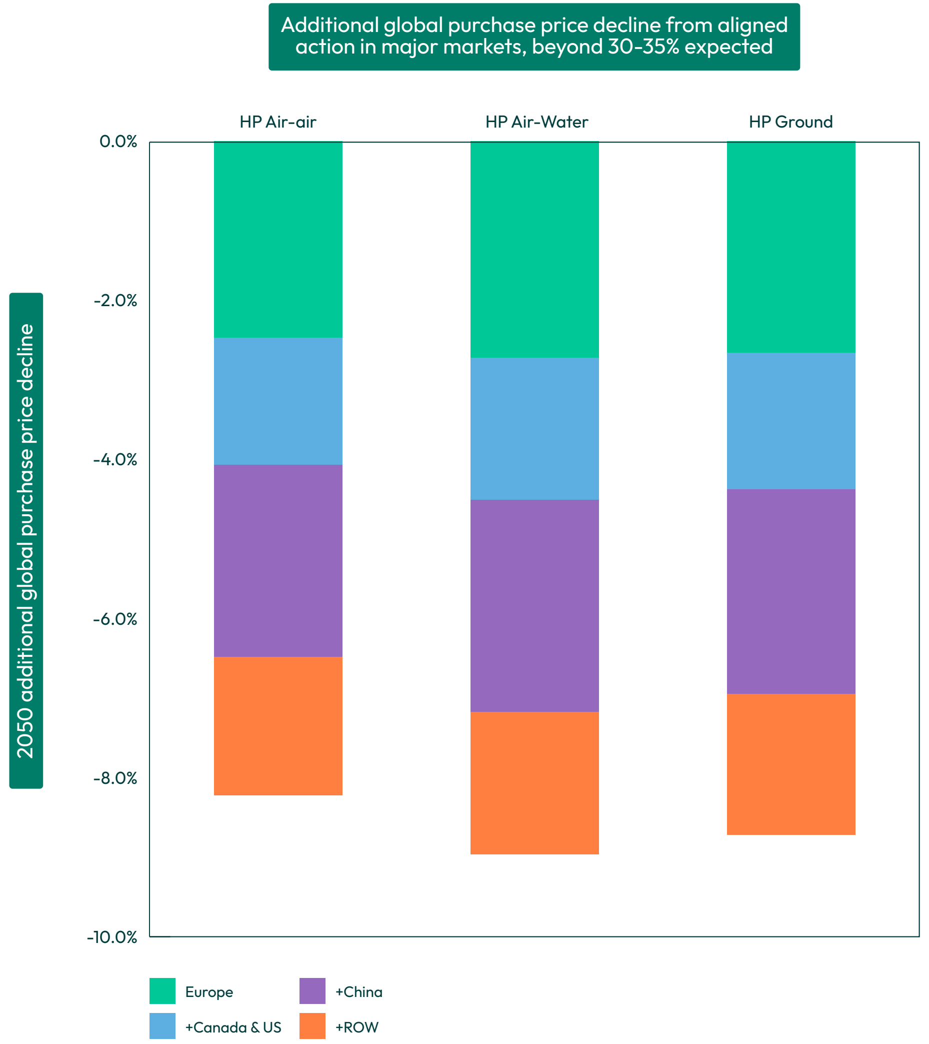
Tax: on fossil fuel boilers set to achieve ownership cost parity with the most expensive heat pump type in 2023.

International action

Aligning action in large markets with a fast transition can accelerate cost declines globally

- **The transition to heat pumps is likely to be less international than the transition to renewables and electric vehicles due to differences between countries in building stock, legacy heating systems, and climate.** These differing circumstances at least partially explain the widely differing purchase costs of heat pumps between countries.
- **Nevertheless, if the largest markets for heating technology align their policies towards heat pumps making up at least 80% of new heating appliance sales by 2035, the purchase price of heat pumps globally could be reduced by an extra 8-9% by 2050, on top of the 30-35% reduction expected on current trends.** This is because a faster transition increases heat pump production and accelerates cost declines through technology learning and economies of scale.
- **The more countries that align their actions in this way, the faster costs will decline.** Since purchase prices remain a significant barrier to heat pump adoption, this could be helpful to all countries.
- **Individual countries can drive their heat pump purchase prices down further** by growing domestic markets, stimulating learning-by-doing, and investing in training to increase the number and productivity of skilled installers [1].
- **International standardisation of heat pump performance requirements or installer qualifications can also help bring costs down.** This is because similar requirements lower the costs of compliance for manufacturers [2].

Sources: [1] NESTA (2022), [2] RAP (2022)

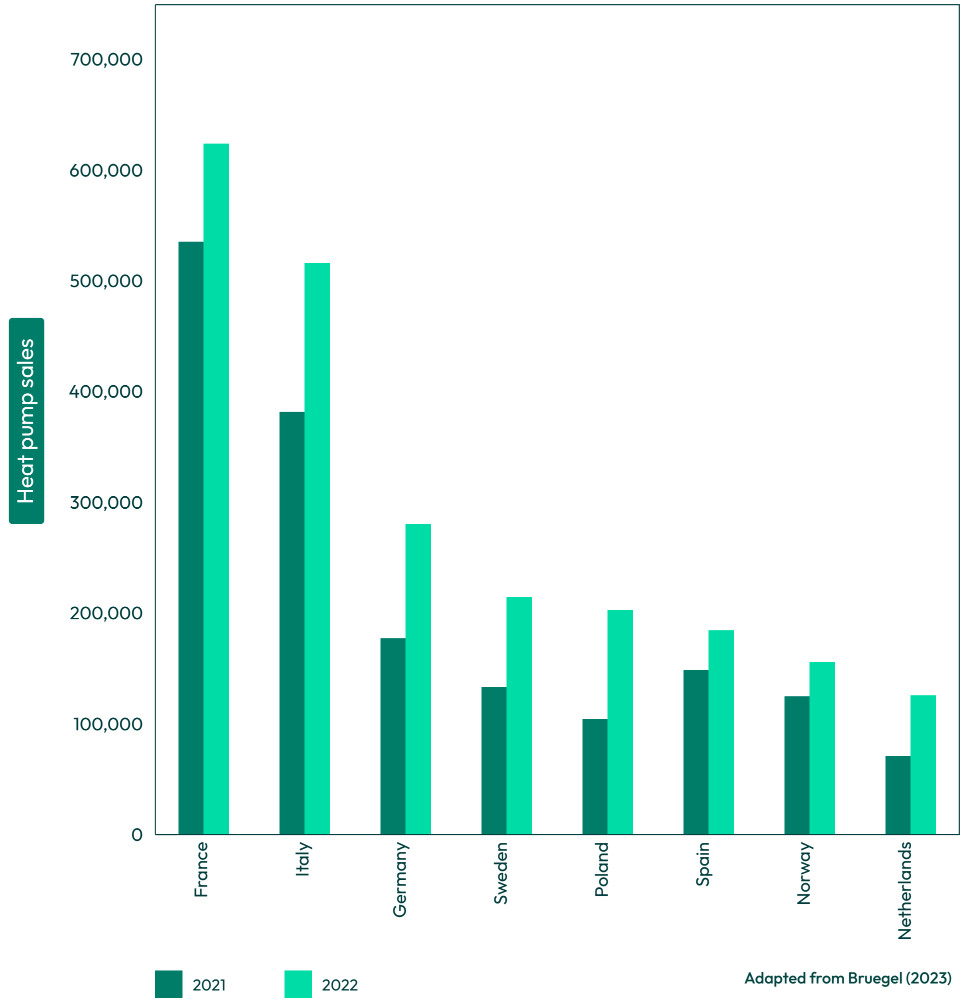


Wider benefits

Decarbonising residential heating can reduce imports and improve energy security

- **80% of the global population lives in countries that are net importers of fossil fuels [1]. In many of these countries, accelerating the deployment of heat pumps can save significant sums on oil and gas imports.** For instance, in the EU alone, €60 billion worth of imports could be avoided by 2030 if gas demand in buildings is reduced by 40% [2].
- **Reducing dependence on imported fossil fuels improves energy security.** Heat pumps protect consumers from energy price spikes which are typically more severe for oil and gas than for electricity [2]. Heat pump adoption in Europe has accelerated in response to the recent energy price spike.
- **Heat pumps can make energy systems more flexible [3] by using heat storage systems to heat up when the demand for electricity is low.** This will require the widespread adoption of digital technologies and many buildings will need improved signals from the electricity grid to communicate when flexibility is required.

Sources: [1] RMI (2022), [2] EHPA (2023), [3] IEA (2022)



Adapted from Bruegel (2023)

Crossing the tipping point

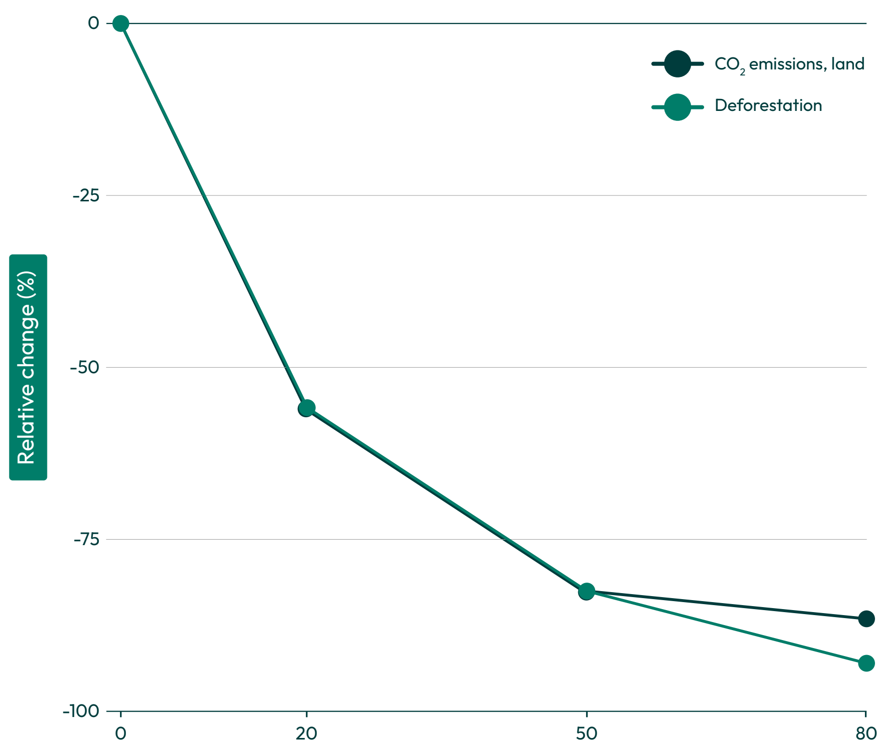
Alternative Proteins Case Study

Plant-based foods and other meat substitutes are critical to cutting emissions

- **Shifts towards more plant-based foods and novel animal protein substitutes such as precision fermentation and cultivated meat can strongly reduce greenhouse gas emissions,** deforestation, land use, water use, eutrophication, and biodiversity loss [1]. This yields trillions of dollars worth of mitigation and food security benefits [2].
- **Rapid reduction of methane emissions is vital to prevent peak warming and reduce climate tipping point risks.** Diet shifts and alternative proteins could cut 645 Mt CO2e/year by 2030 and 1.85 Gt/year by 2050 [2].
- **'Planetary health' diets,** those rich in plant-based foods, can reduce food-system associated emissions by around 50%, and prevent approximately 11 million deaths per year from diet-related diseases [3].
- **Novel plant-based proteins** have an environmental impact orders of magnitude smaller than animal equivalents [4]. One plant-based burger creates 89% fewer emissions than its beef-burger equivalent [5].
- **Precision fermentation** uses yeasts, fungi, mycelium, and other microbial proteins to produce ingredients almost identical at the molecular level to animal proteins [6]. Replacing just 20% of global beef consumption with microbial protein could halve annual deforestation and carbon dioxide emissions, especially methane, associated with it [7].
- **Cultivated meat** is produced directly from animal cells and is identical to conventional meat at the cellular level. It could use land up to 3 times more efficiently than poultry and 10 times more efficiently than beef [8].

Sources: [1] IPCC (2023), IPCC (2022) [2] IPCC (2022), ClimateWorks (2023) [3] Willet et al (2019) [4] GFI (n.d.) [5] Khan et al (2019), GFI (2021) [6] Planet A Ventures (2023) [7] Guglielmi (2022) [8] Sinke et al (2023)

Eating one fifth less beef could halve related emissions and deforestation



Percentage of beef substituted with microbial protein

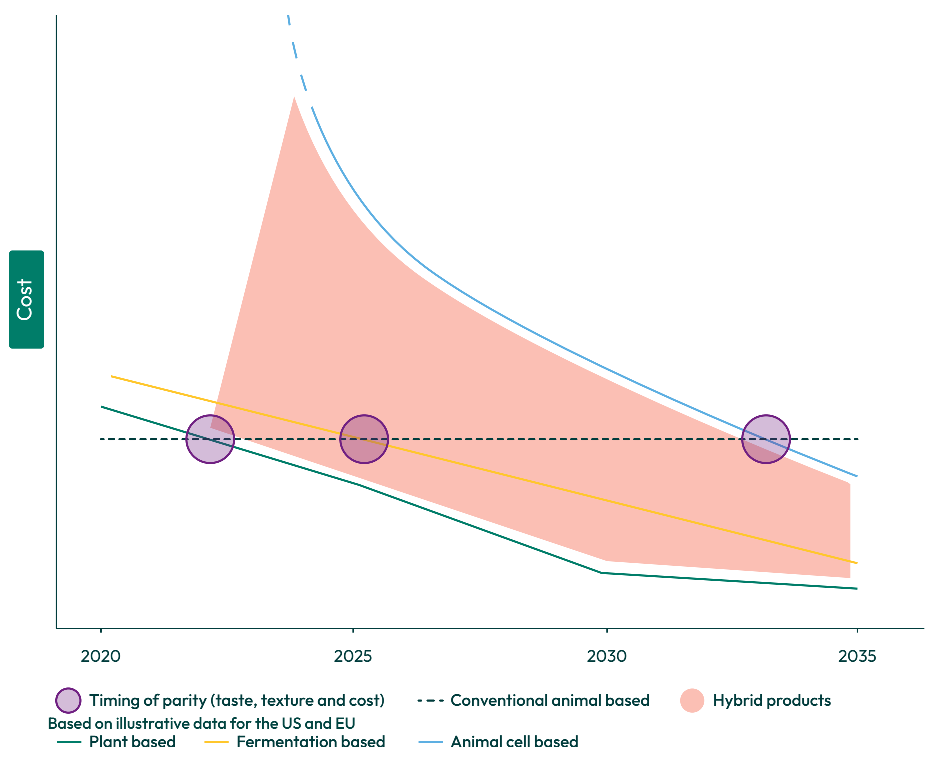
Source: Guglielmi (2022)

Cost parity can be enabled this decade

- **Despite uncertainty of the speed at which cost parity between alternative and conventional meat proteins will be reached, there is confidence that it can and will be reached,** given cost reductions driven by learning, economies of scale, and increasing investment.
- **Various projections for the EU and US indicate that subject to further action by governments, investors and businesses, cost-parity for selected plant-based, precision-fermented and hybrid meat can be reached between now and 2030,** with cultivated meat products able to reach cost-parity in the early 2030s [1].
- **Individual products in these categories are already beginning to undercut conventional meat options** in countries such as the UK, US, and Germany. Brands such as Beyond Meat and Impossible Foods aim to undercut conventional meat prices as early as 2024. In October 2023, Lidl, a supermarket, announced it would ensure price-parity for all its own-brand plant-based meat alternatives in Germany.
- **A 'planetary health' diet is already cheaper than current (high-meat) diets today.** A 2021 study of 150 countries found planetary health diets to be between 22% and 34% cheaper than current diets in upper-middle-income and high-income countries [2].
- **A major barrier to cost parity for all alternative proteins is created by subsidies and public R&D funding** that are significantly higher for animals and their feed than for plant-based food products and alternative proteins [3].

Sources: [1] Morach et al (2022), Rethink X (2019), McKinsey (2021) [2] Springmann et al (2021) [3] Vallone & Lambin (2023)

Projected timing of cost parity for different product types if further actions are taken



Source: Morach et al., (2022)

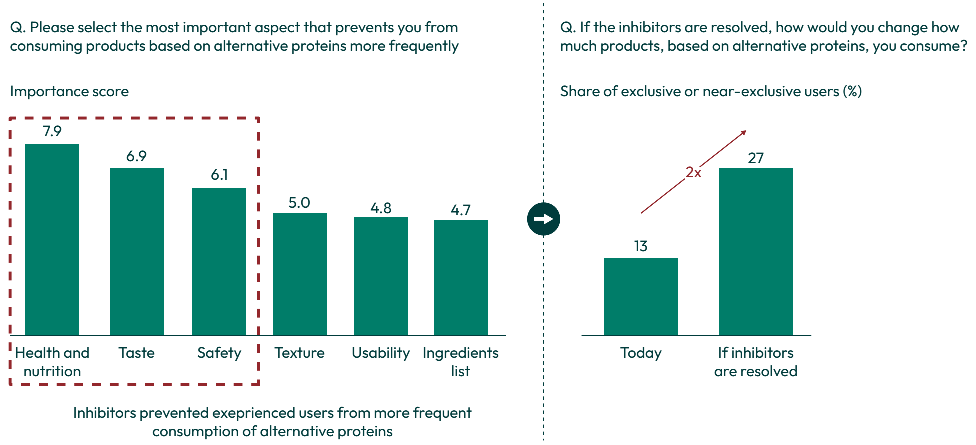
Alternative Proteins

Quality parity is feasible

- **Quality is key to consumer shifts** to meat alternatives. Once alternative proteins are as good as animal proteins in taste, texture, nutritional value and safety, and well as in price, rapid consumer uptake is likely [1]. Policy, investment, and innovation can make this happen.
- **Quality parity is within reach, with some projections estimating that combined price, taste and texture parity will be feasible for different alternative proteins by 2035** [2]. It is most likely to be achieved first for ground meat (used for mince-meat) and later for tissues (such as steak).
- **In precision fermentation, quality improvement is being supported by advances** and cost declines in technologies such as computing, data storage and genome sequencing. These technologies are enabling food scientists to more cost-effectively engineer food for quality, nutrition, taste and structure [3].
- **Hybrid forms of alternative proteins are likely to reach both quality and price parity the earliest,** by combining the texture created by plant-based processing innovations, with the taste and micro-nutrients from precision-fermentation processes, and the fat from cultivated meat processes [4].
- **Public funding for open-access R&D can accelerate learning and product improvement.**

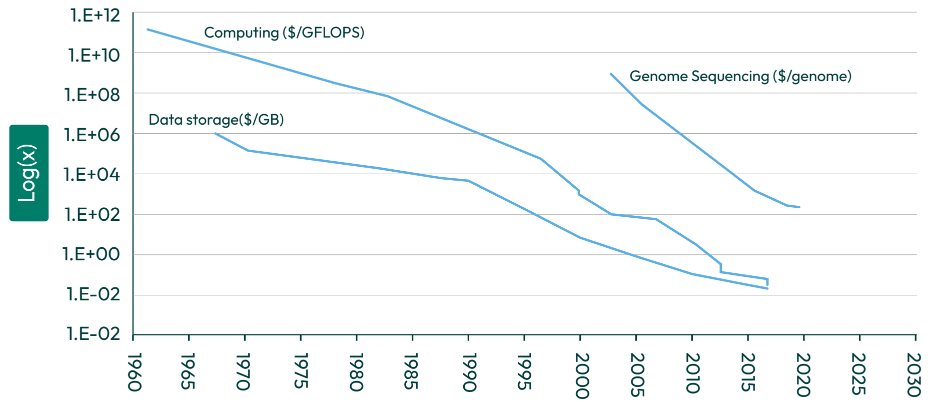
Sources: [1] Morach et al (2022), Fesenfeld et al (2023) [2] Morach et al (2022) [3] Augustin et al (2023) [4] Rubio et al (2020)

Customer willingness to consume alternative proteins if barriers are overcome



Source: Blue Horizon & BCG Customer Survey (Feb-April 2022) in Morach et al., (2022)

Cost of key underlying technologies falling exponentially



Source: Rethink X (2019)

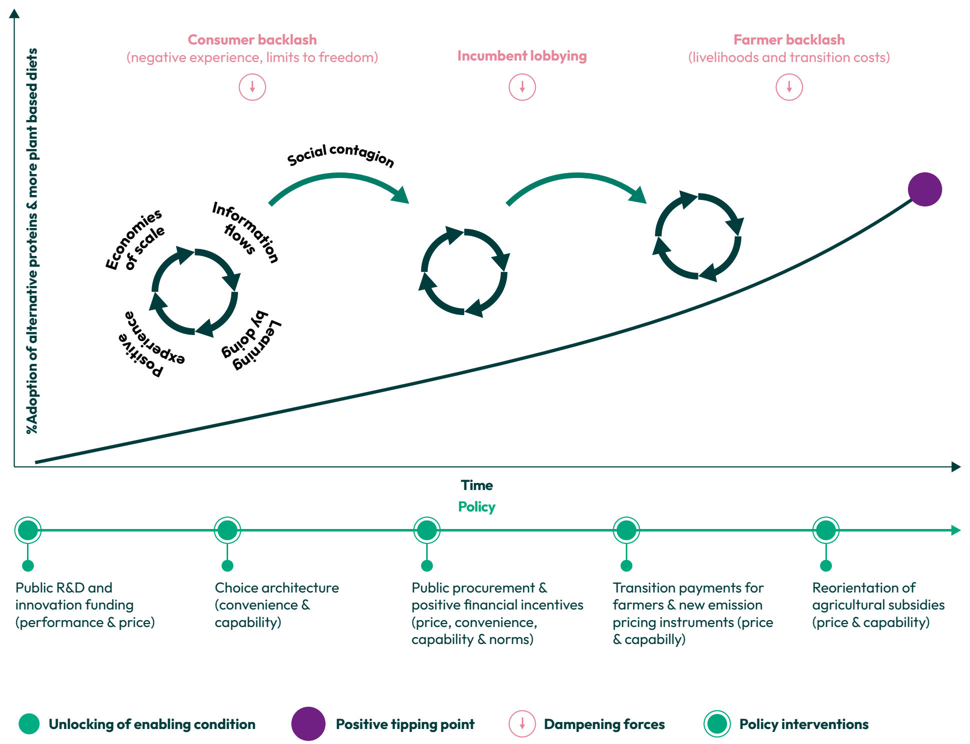
The right policies at the right times can bring forward tipping points

Policies can create feedback loops that accelerate progress and build social support [1]. A positive feedback can operate between increasing production, falling costs, product improvements, positive consumer experiences, and increasing awareness and demand.

1. **Public funding for R&D, open-access research, and scaling up infrastructure** (e.g. manufacturing facilities) can accelerate product improvement, de-risk private investments and foster emergence of new business models.
2. **Changes in how choices are presented to consumers in supermarkets, restaurants, and cafeterias are also vital to shift consumer demand,** by making it easier, cheaper and more enjoyable to buy and consume plant-based foods.
3. **Public procurement & positive financial incentives can grow the market for plant-based foods and animal protein substitutes, incentivising further private investment.**
4. **Targeted transition payments that make it easier for farmers** to shift towards plant-based food production can help build social support for the transition. New emission pricing schemes can encourage the production and consumption of more sustainable alternatives.
5. **Reorienting agricultural subsidies and R&D funding away from animals and towards plant-based foods and alternative proteins could be particularly powerful.** The political feasibility of this can be increased by each of the policy measures outlined above [2].

Sources: [1] Fesenfeld (2020), FOLU (2021), Fesenfeld et al, (2020); Fesenfeld et al, (2022); SDSN (2023) [2] Fesenfeld (2024)

Strategic policy sequencing can accelerate momentum



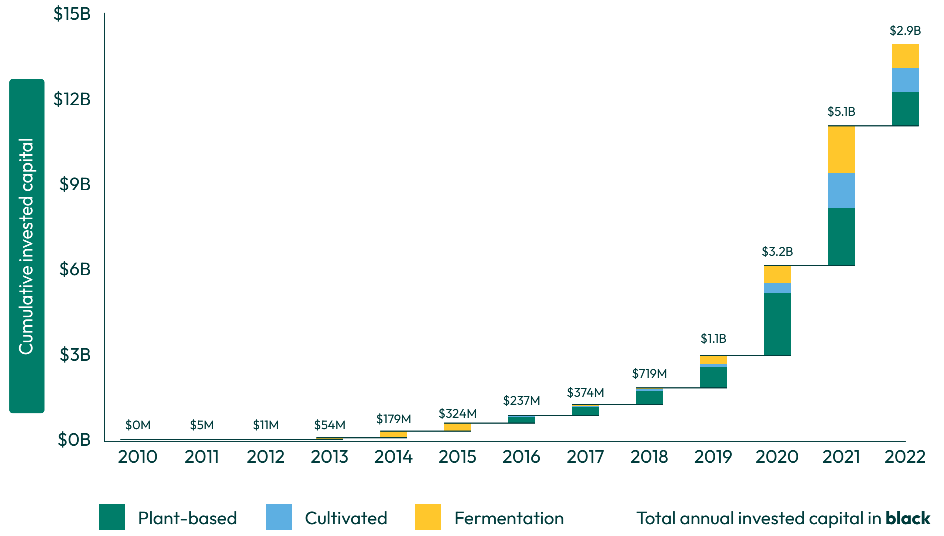
Source: adapted from FOLU (2021)

It's time for public funding to catch up with private investments in alternative proteins

- **Private investment in alternative proteins is growing strongly,** especially in fermentation- and culture-based production [1]. The amount invested in 2021 was a thousand times as much as the amount invested in 2011.
- **Public investment can help businesses scale up.** Globally, around $4.4 billion/year public spending on R&D and $5.7/year billion on commercialization is needed [2]. Denmark's Fund and Action Plan for Plant-based food uses innovation funds, subsidies, support for processing equipment, advice for start-ups and initiatives to attract investment in plant-based foods throughout the value chain. This de-risks expensive infrastructure investments, improves price and quality, and supports market growth.

Sources: [1] GFI (2022) [2] UK's Foreign, Commonwealth & Development Office & ClimateWorks Foundation (2021)

Alternative protein investment is increasing exponentially



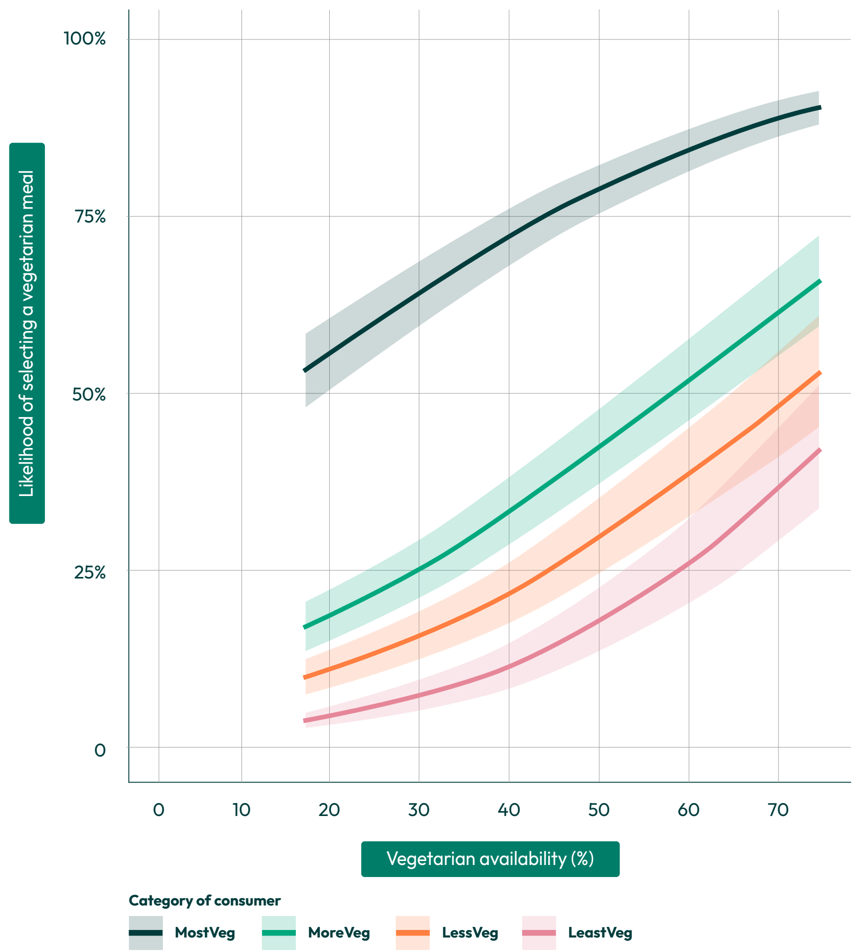
Source: GFI (2022)

Enable sustainable choices: Alternative proteins are chosen more when visible and accessible

- **Changes in the consumer choice architecture in public cafeterias, restaurants and supermarkets can enable rapid dietary changes, especially among heavy meat eaters.** Governments can fund behavioural insights teams that support changes in consumer choice architectures. Simple measures like changing the position and increasing the availability and share of plant-based foods are among the most effective ways to change choices.
- **In an experimental study of UK cafeterias,** doubling the plant-based meals offered (e.g., from 1 in 4 to 2 in 4 options) led to an increase in sales between approx. 40% and 80% within weeks, with the largest behaviour change among the highest meat-eaters [1].
- **Increasing consumer experience with plant-based meats and animal protein substitutes can trigger positive societal and political feedbacks.** Good experiences increase demand, leading to greater investment, improving quality, and reducing costs. Increasing consumer experience is one of the strongest predictors of dietary change and support for policies to promote more sustainable food [2].

Sources: [1] Garnett et al., (2019) [2] Fesenfeld et al (2023)

More plant-based options increased uptake in public cafeterias



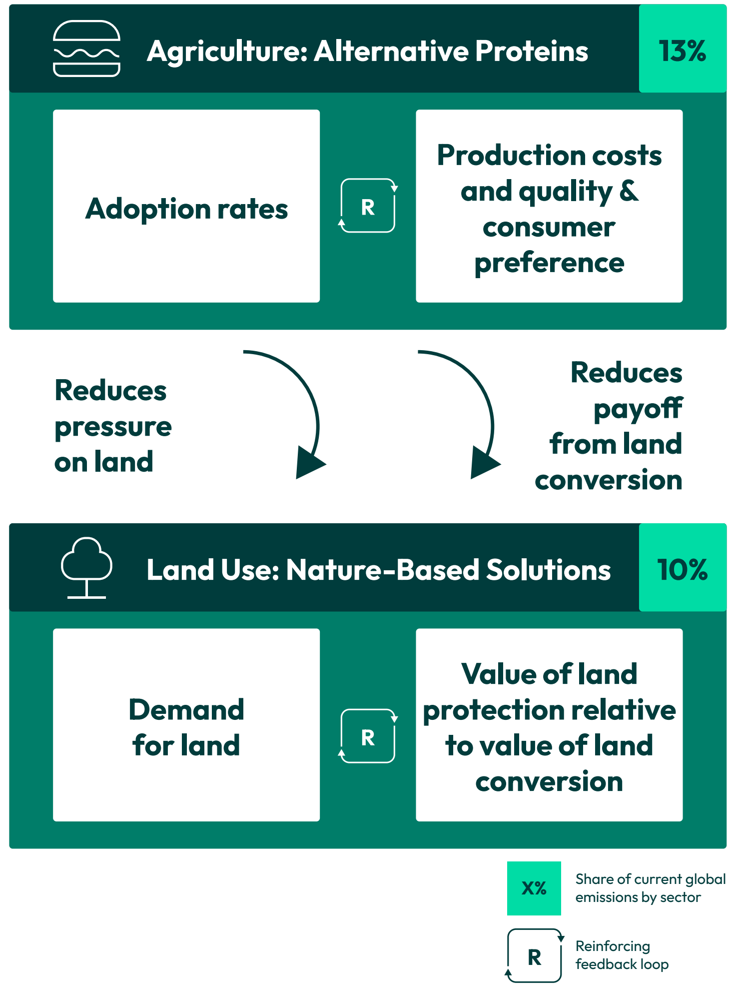
Source: Garnett et al., (2019)

Public procurement & financial incentives can grow the alternative protein market

- **The use of public procurement to increase demand for alternative proteins, and help producers achieve economies of scale and lower costs, offers one of the most powerful policy levers for accelerating the tipping point [1].**
- **Public procurement can meaningfully increase the market share of plant-based products and alternative proteins,** because it often accounts for significant food sales (5-6% in the EU and the UK). Its use also exposes more people to alternative protein products, improving accessibility and shifting social norms [1].
- **It is a particularly powerful lever as it does not require significant additional government expenditure** – instead, existing budgets can be redirected from animal proteins [1].
- **There is a precedent of using public procurement to shift dietary habits:** green public procurement criteria are already used in France, Sweden, Denmark, Italy, Norway and Brazil (e.g. demanding a minimum percentage of produce be organic or local) [2].
- **Enabling alternative proteins to reach 20% market share by 2035 would free up an estimated 7-15% total agricultural land, and reduce the value of converting land relative to the value of protecting it** [1]. The combination of its cost-effectiveness and cascading impact across agriculture and land use make it a critical policy lever.

Sources: [1] Systemiq (2023) [2] EC (2018), GPF (2013)

Redirecting public procurement to promote the uptake of alternative proteins



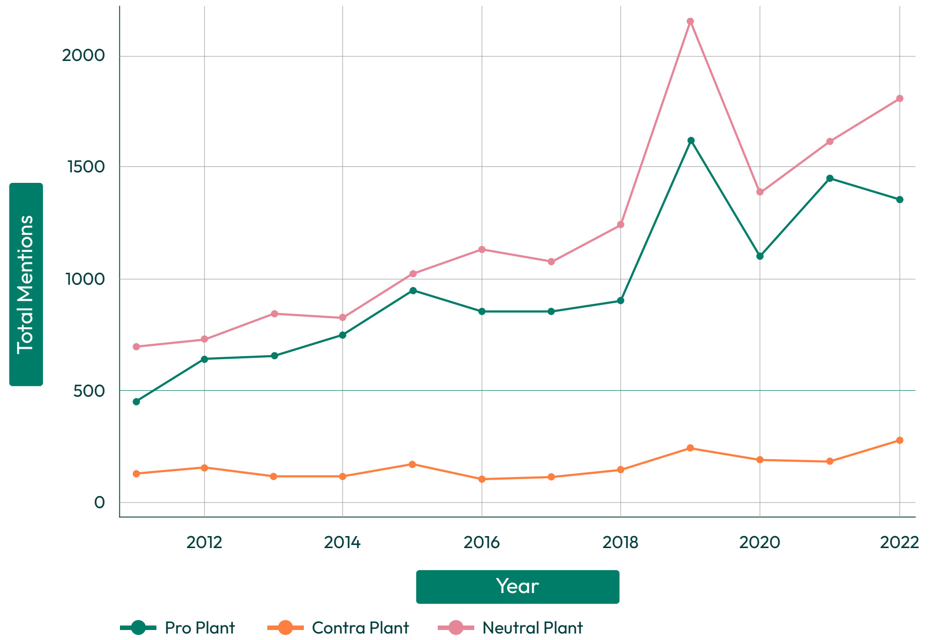
Source: Systemiq (2023)

Social support for the transition is growing. Get farmers on board with transition payments

- **In leading markets around the world, public discourse, public opinion, and social norms are shifting in favour of more plant-based diets** and animal protein alternatives, driven by availability and positive experience [1].
- **Transitioning towards alternative proteins and more plant-based foods can lower food prices, reduce food security concerns, and create 83 million jobs globally by 2050** [2].
- **Even costly policies like new animal welfare levies or emission pricing of food are supported by a majority of citizens when bundled together** with higher producer standards, tax revenue recycling to lower income households, and reduced prices for plant-based food [3]. Reducing VAT and sales tax rates for plant-based products can shift demand and also reduce costs for low-income households.
- **Moving to more plant-based food consumption overall has positive income effects for farmers [4], but the transition will be most difficult for producers of animal meat and animal feed [5].** Governments can support farmers by providing transition payments, as Denmark does, and by supporting the development of new business models such as agriculture combined with renewable energy production and carbon markets. Support for the transition can also be provided at regional level.

Sources: [1] Fesenfeld et al (2023) forthcoming, Fesenfeld (2021) [2] Sun et al (2022), ClimateWorks (2023) [3] Fesenfeld et al (2023) [4] Rieger et al. (2023) [5] Moray-da-Silva (2022)

Media statements increasingly favour plant-based foods



Based on a natural language processing analysis of over 500’000 media reports from the two most populated countries per continent, the graph shows the share of media statements in favour (pro), neutral, and against (con) plant-based food.

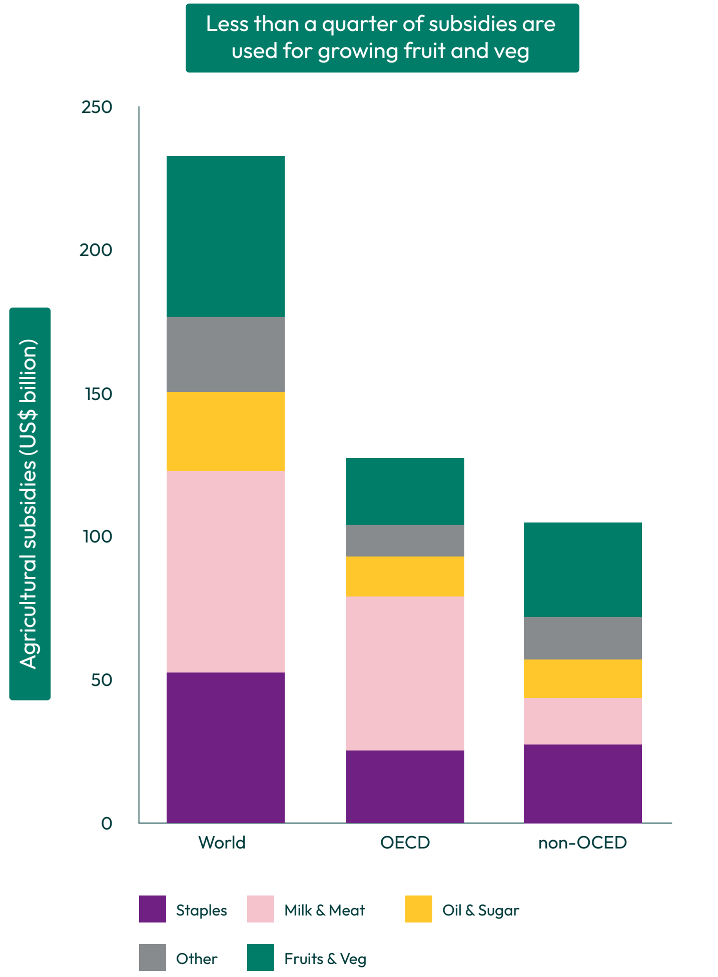
Source: Fesenfeld (2024)

Alternative Proteins

A reorientation of agricultural subsidies becomes possible through the measures above

- **Less than a quarter of global agricultural subsidies are used for growing fruit, vegetables, legumes and nuts** [1].
- **Reorienting agricultural subsidies and R&D funding away from animals and towards plant-based foods and alternative proteins could be particularly powerful [2].** This can be done by making a part of the subsidies conditional on growing plant-based foods and alternative proteins.
- **The political feasibility of this will increase as new industry coalitions grow and strengthen** [3].

Sources: [1] Springmann & Freund (2022) [2] Vallone & Lambin (2023) [3] Fesenfeld, 2020, FOLU, 2021, Fesenfeld et al, 2020; Fesenfeld et al, 2022; SDSN Expertpanel, 2023



Source: Springmann & Freund (2022)

Series authors: **Anna Murphy & Simon Sharpe**

Case study authors:

- Electric vehicles: **Anna Murphy, Aileen Lam, Jean-Francois Mercure & Simon Sharpe**
- Solar and storage: **Lilia Caiado Couto, Anna Murphy, Femke Nissje & Simon Sharpe**
- Heat pumps: **Cormac Lynch, Femke Nijsse, Despina Georgiadis, Alex Edwards Simon Sharpe & Anna Murphy**
- Hydrogen: **Anna Murphy, Simon Sharpe & Lilia Caiado Couto**
- Alternative proteins: **Lukas Fesenfeld, Maiken Maier, Sol Kislig, Anna Murphy & Simon Sharpe**

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